CHARTING COMMON GROUND

FOR

SALMON AND BUILDINGS

Prepared By:

Center for Maximum Potential Building Systems
Austin, Texas

December 2002

Acknowledgements

This report was funded by The Bullitt Foundation and the City of Seattle departments of Seattle Public Utilities and Seattle City Light. The authors are solely responsible for the content.

The Project Manager and Principal Author of this report is Gail Vittori, Co-Director, Center for Maximum Potential Building Systems. Contributing authors are CMPBS' Richard MacMath, who oversaw the BaselineGreen™ component of the report, Pliny Fisk III, and Michael Gatto, with research assistance provided by Katie Sternberg and Sharon Joyce. The BaselineGreen™ analyses were prepared by Greg Norris, Ph.D., Sylvatica, Inc. The graphic design was prepared by Adele Houghton.

The maps were prepared by CMPBS GIS Specialist Heidi Dues, EcoTrust, Portland, Oregon and Commenspace, Seattle, Washington.

We extend thanks to the reviewers from the City of Seattle who provided invaluable comments and include: Lucia Athens, Seattle Public Utilities; Lynn Best, Seattle City Light; Jack Brautigam, Seattle City Light; Peter Dobrovolny, Seattle City Light, Kim Drury, Office of Sustainability and Environment; Corinne Grande, Seattle City Light; Steve Moddemeyer, Seattle Public Utilities; Thor Peterson, Seattle Public Utilities.

Disclaimers
While every effort has been made to thoroughly research the topics presented herein to ensure technical accuracy, the authors are not salmon biologists nor Seattle City staff. As such, any discrepancies relative to fact or policy-related issues should be considered errors. Please notify the authors of any errors that are found.

The City of Seattle, Seattle Public Utilities, and Seattle City Light, while co-funders of this research project, are not the authors of this report and recommendations, and take no responsibility for the data or recommendations contained herein.

For more information on the City of Seattle's Sustainable Building Program, see www.cityofseattle.net/sustainablebuilding.

Table of Contents

Executive Summary 5

Introduction – Salmon and Buildings 11

Motivation – Salmon Decline 11

Objective and Scope 13

Organization of this report 17
Methodology – LEED™ 17
BaselineGreen™ – Summary of Method 17
Human-Induced Environmental Burdens 18
Recommended Strategies 21

LEED™ Based Analysis 23

Sustainable Sites 25 SS
Impact to Salmon 25
Salmon-Friendly LEED™ Overlay 29

Water Efficiency 31 WE
Impact to Salmon 31
Salmon-Friendly LEED™ Overlay 33

Energy and Atmosphere 35 EA
Impact to Salmon 36
Salmon-Friendly LEED™ Overlay 39

Materials and Resources 41 MR
Impact to Salmon 41
Salmon-Friendly LEED™ Overlay 58

Indoor Environmental Quality 63 IEQ
Impact to Salmon 63

Innovation and Design Process 65 ID
Materials and Resources 65

Conclusions 67

Summary of Findings and Recommendations 67

Further Study 70

Concluding Remarks 71

73 Notes

77 Appendix A: BaselineGreen™ Report

133 Appendix B: Wingspread Statement on the Precautionary Principle

135 Appendix C: Salmon-Friendly LEED™ Overlay

Executive Summary

Charting Common Ground for Salmon and Buildings was prepared as part of a sustained effort by the City of Seattle to reconcile the needs of the natural environment with those of the region's human inhabitants, with a specific focus on the interplay between salmon and people. While there is compelling evidence that building related industries, the construction process, and the operation and dismantling of buildings affect the environment in general, what is not so clear is the extent to which these dynamics affect salmon. Paralleling efforts focused on Salmon Friendly Gardening practices, as developed by Seattle Public Utilities, and the Salmon-Safe™ Farm Management Certification Program, as originally developed by The Pacific Rivers Council, Inc. and now under the auspices of Salmon-Safe Inc., this report explores how buildings fit into the salmon decline puzzle, and establishes a framework to identify buildings' direct and indirect contributions to this decline. Additionally, guidelines are offered that identify specific strategies to lessen the building-related burdens imposed on salmon and their habitat.

The report notes a disturbing long term trend: the decline of wild salmon in the Pacific Northwest. Indeed, the numbers are staggering: according to the most recently published sustainability indicators report for the Seattle region, local wild salmon runs declined by 50% to 75% from the mid-1980's until the early 1990's at which time they stabilized at dangerously low levels. And, while significant study has assessed the relationships between *where* buildings are located and salmon habitat decline, much less study has focused on the aggregate toll that buildings through their life cycle have on salmon and the waters in which they live. While the boundaries for this study are broad, this inquiry is narrowed to a few key building-related spheres of influence that represent either a high mitigation potential or for which little primary research has been undertaken:

- generic *site* issues (independent of building location)
- *upstream* material environmental burdens – the BaselineGreen™ analysis
- building *use* phase impacts
- *downstream* material environmental burdens

Reflecting the uncertainty inherent in assigning precise cause and effect relationships, we introduce the precautionary principle as a basis to establish association between particular actions and outcomes connected to decline, summarized in the following statement:

> "Where an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."

The U.S. Green Building Council's LEED™ (Leadership in Energy and Environmental Design) green building rating system serves as the report's organizational framework, while the upstream environmental burden data associated with building materials is derived from BaselineGreen™ which identifies three impact categories (greenhouse gases, criteria air pollutants, and toxic releases) linked to the bill of materials for new single-family residential, new office, and new retail construction in the tri-county region (Snohomish, King, and Pierce).

The principal conclusion of the BaselineGreen™ analysis is that the upstream impacts of building materials on salmon in the tri-county region, in *quantitative* terms, is relatively small, particularly when compared to impacts associated with other regional industries. Moreover, although the three BaselineGreen™ analyses indicated that, for average construction in the entire U.S., many building related materials and products are associated with upstream toxic releases, air pollution, and greenhouse gas emissions, *the data suggest that local and regional industries in Seattle and the State of Washington are "cleaner and greener" than the U.S. average.* State of Washington toxic release data from 1999 associated with building-related industries reveal relatively small documented toxic releases to water, no toxic releases to land, and toxic releases to air less than 5% of the statewide total. Therefore, specifying materials and products from local and/or regional manufacturers will not necessarily result in an increase in associated upstream environmental burdens at the local and regional scale, and may, in the case of Washington, *improve* the environmental performance as compared with national averages. With the exception of cement and fabricated steel products, the same can be said for Washington State's upstream criteria air pollutant and greenhouse gas emissions.

For the five areas tracked by BaselineGreen™ — toxic releases to water, toxic releases to land, toxic releases to air, criteria air pollutants, greenhouse gas emissions – our findings are:

- **Toxic releases to water**:
  Compared to other industries such as paper manufacturing, building related industrial toxic releases to water reported in 1999 were less than 1 percent. This is true for both the three county region and the rest of the State of Washington. These releases to water were made by three wood treatment facilities, one of which is located in the tri-county region.
- **Toxic releases to land**:
  With the exception of waste disposal, building related industrial toxic releases to land reported in 1999 were zero. This is true for both the three county region and the rest of the State of Washington.
- **Toxic releases to air**:
  Compared to other industries, building related industrial toxic releases to air in 1999 were relatively small. The percentage of statewide reported toxic releases to air that can be attributed to building related industries is less than 5% of the total.
- **Criteria air pollutants**:
  With the exception of cement, building related industrial criteria air pollutant releases in 1999 were relatively small. The cement industry accounts for a significant share of all types of criteria air pollutant emissions in the three county region.
- **Greenhouse gas emissions**:
  Emissions of CO_2 associated with the manufacture of cement and fabricated steel products account for a substantial portion of greenhouse gas emissions in the three county region and possibly a large portion of greenhouse gases in the rest of the State of Washington. Two cement plants and one lime facility in the tri-county region account for approximately 1.4 million tons of CO_2 emissions per year, while

the CO_2 emissions total for the steel product manufacturer located in King County is about 250,000 tons per year.

However, the BaselineGreen™ findings may not tell the whole story due to possible weaknesses in the TRI data. These include the potential for industry misreporting of emissions, the provision for small quantity generators to avoid reporting requirements, and the potency associated with persistent bioaccumulative toxins (PBTs) as a class of chemicals, and other highly toxic chemicals, that may not be reflected in the way data are currently reported, nor account for the cumulative, long-term and synergistic effects of multiple chemical releases.

With the BaselineGreen™ analysis not revealing a substantial *direct* link to salmon decline, our study pursued five other possible building related activities as having a potentially greater impact on salmon habitats in the region:

- **Stormwater Runoff & Impervious Cover**:
  The rule of thumb is that watershed health is threatened when impervious cover exceeds 10%. Since most of Seattle exceeds this level, we concur with Seattle's current aggressive stormwater management practices and strict contaminant control of runoff consistent with the State of Washington Department of Ecology's "Stormwater Management Manual for Western Washington".
- **Salmon-Friendly Hydro, Greenhouse Gas Emissions, & Ozone Depletion**:
  The City of Seattle should be commended for its attention to the potential damaging affect of hydro facilities on salmon with the upgrading of its hydro facilities to ensure that there is no blockage of salmon passage, in addition to meeting the requirements of the Low Impact Hydropower Institute. While hydro does not contribute to greenhouse gas emissions, several building related industries in the tri-county region do, most notably the two cement kilns located on the Duwamish Waterway. Efforts to mitigate greenhouse gas emissions should be pursued, as should the substitution of alternative cements, such as fly ash, to reduce the net CO_2 impact of concrete on salmon. The release of CFCs and HCFCs contributes to stratospheric ozone layer depletion, resulting in increased exposure to ultraviolet radiation, to which salmon have vulnerability. Our analysis found two manufacturers in the tri-county region using CFCs, despite their ban as of 1996. We recommend no allowance for continued use of CFCs, and an accelerated phase-out of all ozone depleting compounds as called for by the Montreal Protocol; at a minimum, compliance with the phase-out scheduled should be verified for all tri-county manufacturers.
- **Sand & Gravel Mining**:
  Washington State is the nation's fifth largest source of aggregates; in the tri-county region alone, gravel mining operations cover over 9,000 acres. The extraction of sand and gravel disrupts habitat and contributes to erosion and sedimentation. We recommend specifying alternative aggregates for concrete mixes, and strict monitoring for all current sand and gravel operations. Policies for grandfathering of permitted facilities should be carefully reviewed to ensure that practices that could contribute to salmon decline are discontinued. Furthermore, with an estimated cost of $50,000, we recommend the City of Seattle, in conjunction with other regional governments, consider pursuing the elements of a study proposed in the 1999 state legislative session (House Bill 1284) regarding sand, gravel, and rock

resource mining and its impact on salmon habitat and urban development, and identify environmentally sound sand, gravel and rock deposits. Current evaluations predict that existing mines will be unable to fulfill future demand for sand, gravel or rock.

- **Forest & Agrifiber Products**:
  Forested lands produce both wood and salmon, with the extraction of wood and related forest practices contributing to loss of salmon habitat. Based on discussions with a certifier for the Forest Stewardship Council (FSC) regarding the accrued benefits associated with FSC certified products, the authors recommend specifying FSC-certified wood products and materials when they are cost-competitive and provide equal or superior performance than non-FSC certified wood products and materials. In addition to choosing products that ensure greater protection to salmon than non-FSC certified sources, this action will help to bolster market demand, and potentially catalyze an increase in FSC-certified forests, recognizing that less than 2% of Washington State's forested acreage is currently FSC certified. Furthermore, to reduce the burden on forests, the authors also recommend increased use of agrifiber products, such as wheat straw board, and support the establishment of wheat straw-based manufacturing businesses in the State of Washington, such has been begun by the Washington Department of Community, Trade and Economic Development.
- **Toxic Chemicals**:
  Toxic chemicals, particularly persistent bioaccumulative toxins (PBTs), pose significant threats to salmon as they accelerate the incidence of chemical effects, such as modification of DNA, and alter immune functions. In 2000 the U.S. EPA issued a general fish consumption advisory for the Puget Sound due to pollutant contamination, some of which were PBTs. Both the State of Washington and City of Seattle have policy initiatives that acknowledge PBTs' environmental health toll. PBTs with direct links to building materials are cadmium, dioxin, lead, and mercury. In July 2002, the Seattle City Council passed a resolution, introduced by City Councilwoman Heidi Wills, to reduce the purchase and use of persistent bioaccumulative toxics, instructing the City to forego the purchase of products that contain persistent chemicals, or that result in the release of persistent pollution during their manufacture. This resolution echoes our recommendation that the City of Seattle phase-out the use of PVC building materials, lead flashing and other lead roofing products as cost-competitive products of equal or better performance become available; specify paints that meet the Green Seal chemical requirements; prohibit cement kilns from burning fuels that release PBTs; and, work with state and regional agencies to ensure proper disposition of mercury containing light bulbs. As noted above, the only toxic releases to water were those emanating from three wood treatment facilities. Because of the broad risks to salmon, CCA (copper chromated arsenic), creosote and pentachlorophenol wood treatment chemicals should be banned in the tri-county region, with an accelerated phase-out of CCA enacted prior to the US EPA December 2003 sanctioned deadline. Seattle's Department of Parks and Recreation is commended for having prohibited the use of arsenate-treated wood products, and for encouraging the use of safer alternatives including reinforced recycled plastic wood.

Our findings also bring focus to the operational impacts of buildings. In the case of water, we note that Seattle Public Utilities' 1% for Conservation program has already yielded strong results, with the utility accomplishing a 1% reduction per year since 1980. Similarly, Seattle City Light's commercial energy code is one of the nation's most stringent providing a solid demand side management plan curbing global warming contributions and the potential for habitat decline associated with hydroelectric facilities.

A related finding is that three of Seattle City Light's six largest electric customers are building-related industries: #1 is Birmingham Steel, with Ash Grove Cement #5 and Lafarge Cement #6. Steel and cement – the products of these factories – represent some of the largest volume and highest value materials used in residential and commercial building sectors. These three companies should be encouraged to continue to explore strategies to enhance operational efficiencies, such as have begun with established partnerships between the City of Seattle and Birmingham Steel, that will yield reduced electrical demand and a reduction in associated emissions.

Finding common ground for salmon and buildings is a work in progress, requiring deliberate alignment of design and construction practices and the methods and materials employed with the defining elements of ecosystem health. To the extent that the Pacific Northwest's salmon population serves as the region's yellow canary, ongoing monitoring and recalibration of best practices related to design and construction – where we build, how we build, what we build with – is vital.

Introduction

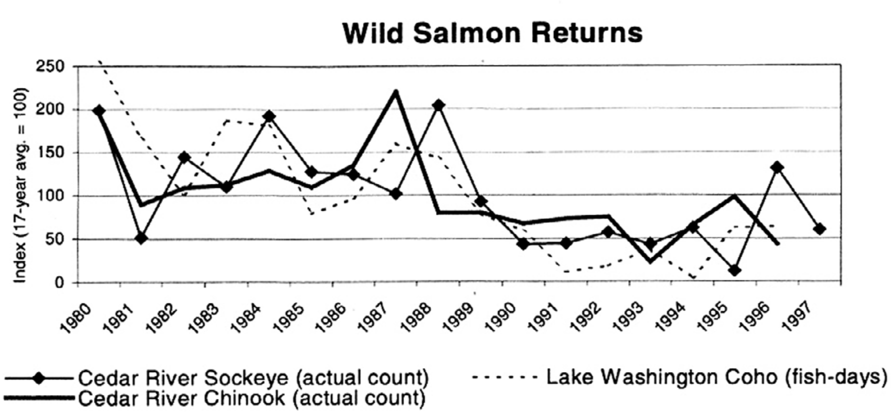
Motivation -- Salmon Decline

This study, commissioned by the City of Seattle with additional support from The Bullitt Foundation, responds to a disturbing long term trend: the decline of wild salmon in the Pacific Northwest. According to the most recently published sustainability indicators report for the Seattle region, local wild salmon runs declined by 50% to 75% from the mid 1980's until the early 1990's at which time they stabilized at dangerously low levels (see Figure 1).[1] The report notes the long-term downward trend as signifying a shift away from sustainability. As illustrated in Figure 2 on the following page, this century long decline has been documented for the Columbia River as well. It is no surprise that the people of Seattle chose wild salmon runs as a sustainability indicator, since salmon's ties to the region's cultural heritage, economy, tourism, recreation, and food production are well established, as is salmon's sensitivity to storm water run-off, drainage from lawns and farms, urban development, forestry practices, dams, and overfishing.

Reflecting the multiple uncertainties associated with specific cause-effect relationships contributing to salmon decline, saving salmon is complex. Indeed, in the last two decades, approximately $3 billion has been spent on restoring salmon in the Pacific Northwest, yet their decline ensues. While seven salmon species are currently listed with the Endangered Species Act, more than 40 salmon and steelhead populations indigenous to Washington State have already become extinct.[2] In a report prepared by the Independent Scientific Review Group, habitat degradation in estuaries, rivers, and oceans was identified as the main cause of the decline in salmon stock, and restoring connected, viable habitats was considered achievable only by returning them to a "normative" state. The dimension of this concern is enormous, as watersheds with salmon and related endangered species cover 71% of Washington State.

As stated above, the enterprise of fixing the salmon problem is elusive, hindered by multiple challenges revealing the intricacies of salmon's ecological underpinnings as well as the uncertainty surrounding the cumulative effects of more than two centuries of increasingly intensive human development. Interestingly, these profound challenges are

Figure 1: Wild Salmon Returns in Washington State



Source: Seattle Sustainability Indicators Report (1998).

Washington Department of Ecology's *Stormwater Management Manual for Western Washington*
excerpt

The engineered stormwater conveyance, treatment, and detention systems advocated by this and other stormwater manuals can reduce the impacts of development to water quality and hydrology. But they cannot replicate the natural hydrologic functions of the natural watershed that existed before development, nor can they remove sufficient pollutants to replicate the water quality of pre-development conditions. Ecology understands that despite the application of appropriate practices and technologies identified in this manual, some degradation of urban and suburban receiving waters will continue, and some beneficial uses will continue to be impaired or lost due to new development. *This is because land development as practiced today, is incompatible with the achievement of sustainable ecosystems. Unless development methods are adopted that cause significantly less disruption of the hydrologic cycle, the cycle of new development followed by beneficial use impairments will continue.*[3] (emphasis added)

Value of Salmon for Human Communities
Stuart Cowan, EcoTrust's Conservation Economy Research Director

"… in a deeper sense, what is good for the salmon is good for human communities. If we are to create "salmon-friendly streets", urban habitats which are conducive to the health of salmon, we will almost certainly find that they are also conducive to human health. Salmon-friendly stormwater and wastewater treatment systems, patterns of resource use, building practices, and riparian buffers have multiple benefits. They may create recreational opportunities, help control flooding, reconnect us with natural cycles, save hard dollars in resource costs, and offer a wide-range of other environmental, social and economic benefits…. In effect, a salmon runs through the conservation economy, reminding us that whole-watershed, whole-systems approaches yield triple bottom line benefits.[7]

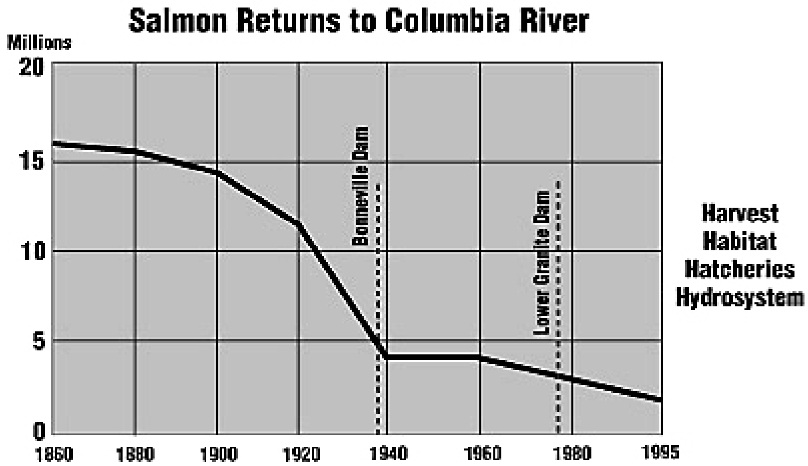
echoed with remarkable consistency from the grassroots to the state bureaucrats. This common voice reveals broad consensus that, short of a fundamental shift of western development practices, settlement patterns and burdens associated with continued population growth, reversing salmon decline is likely unachievable. (See sidebar)

In its report, *Upstream: Salmon and Society in the Pacific Northwest*, the National Research Council identifies continued population growth as a compounding factor, stating that efforts to save natural salmon runs by reducing per capita impacts through conservation measures, improved land use practices, improved dam passage, and better riparian protection, could be undermined by continued regional population and economic growth.[4] Put in a regional context, between the 1990 and 2000 censuses, Washington State grew by more than 1 million people to 5,894,121, a 21 percent increase,[5] with continued growth projected well into the 21st century. The population of the Seattle-Tacoma-Bremerton Metropolitan Area, currently at 3.5 million people, is projected to increase to 5.5 million by the year 2025.[6] Thus, the potential to lessen burdens by adopting salmon-friendly practices may be negated by the shear volume of construction activity associated with burgeoning population.

Further complicating the challenges associated with better-informed design and building practices is the legacy of more than a century of habitat disruption. Although not included in the scope of this report, remediation and restoration hold as much, if not more, importance for the resurgence of salmon than best practices applied to buildings in the pipeline today. That salmon still exist at all speaks more to their resilience than to the best-informed and intentioned contemporary design and construction methods and materials.

However, rather than forecasting failure, challenges such as have been raised point the compass in a clear direction: comprehensive and systemic transformation of the human footprint on the land. (see sidebar) Salmon are highly sensitive animals, and, as such, provide a barometer of ecosystem health. Moreover, salmon have intrinsic value as highly evolved species comprising their own unique aspect of the ecosphere. Thus the motivation for this study derives from both the *intrinsic* and *indicator* value of salmon.

Figure 2: Wild Salmon Returns to Columbia River



Source: www.nwd.usace.army.mil/ps/colrvbsn.htm

Objective and Scope – Buildings and Salmon

While significant research has assessed the relationships between *where* buildings are located and salmon habitat decline, there has been less focus on the aggregate toll that buildings through their life cycle – their materials of construction, the resources they consume to operate, the by-products they generate – have on salmon and the waters in which they live. Building on parallel efforts focused on Salmon Friendly Gardening practices, as developed by Seattle Public Utilities, and the Salmon-Safe™ Farm Management Certification Program, originally developed by The Pacific Rivers Council, Inc. and now under the auspices of Salmon-Safe Inc., Portland, Oregon, this report explores how buildings fit into the salmon decline puzzle, and establishes a framework to identify buildings' direct and indirect contributions to this decline. Additionally, guidelines are offered that identify specific strategies to lessen the building-related burdens imposed on salmon and their habitat. Illustrating the pivotal role that buildings play, a draft report released by the Northwest Fisheries Science Center found that the areas determined to be the "worst" locations for salmon stocks had less than 1% urban/built land cover, suggesting that stocks are sensitive to even minor variations in urban development.[8] Indeed, a survey of life cycle building-related activities and dependencies reveals multiple breaches to the ecological integrity of the habitats of salmon and other species. Among these are increased impervious cover, alteration of water quantity and quality, transformation of fragile forest ecosystems, release of persistent bioaccumulative toxins, and extraction of finite mineral stocks.

Figure 3 illustrates the four distinct phases of a building's life cycle. Such a life cycle perspective is important to properly value the salmon-friendly strategies. Similarly, additional costs associated with suggested environmental mitigation strategies should be viewed in a life cycle cost context, as in many cases higher first-cost investments can offset anticipated economic burdens associated with conventional practices. Thus,

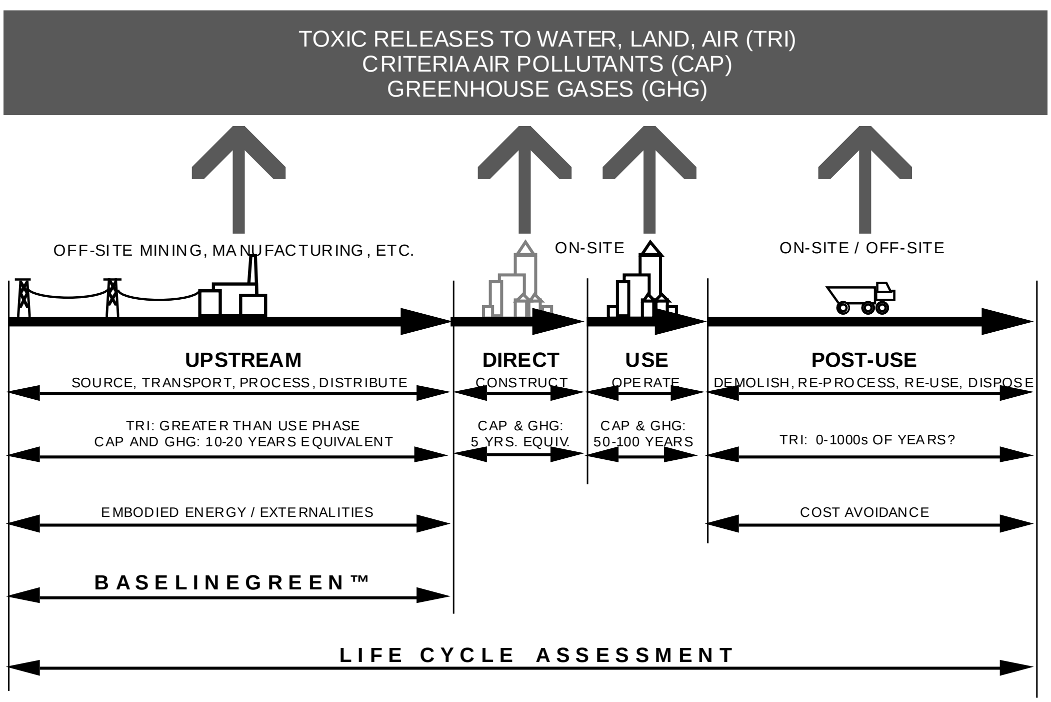


Figure 3: Relative Impact of Toxic Releases, Criteria Air Pollutants, and Greenhouse Gas Burdens Throughout an Entire Building Life Cycle

Toxic releases to water, land, and air, as well as air pollution and greenhouse gas emissions are associated with each stage of a building's life cycle. Upstream manufacturing of building materials and products typically accounts for a higher amount of toxic releases than other life cycle stages of a building. However, upstream manufacturing of building materials and products typically account for a much lesser amount of air pollution and greenhouse gas emissions than the use life cycle stages (occupancy) of a building. Typically, environmental burdens from energy consumption from fossil fuel generated sources and maintenance and repair activities outweigh upstream burdens. The post-use (downstream) stage of a building's life cycle may pose public health risks and environmental impacts if the materials and products used in the building contain hazardous substances (e.g., asbestos or lead). The BaselineGreen™ analysis examines the environmental burdens associated with the upstream life cycle stage.
[Figure by the authors.]

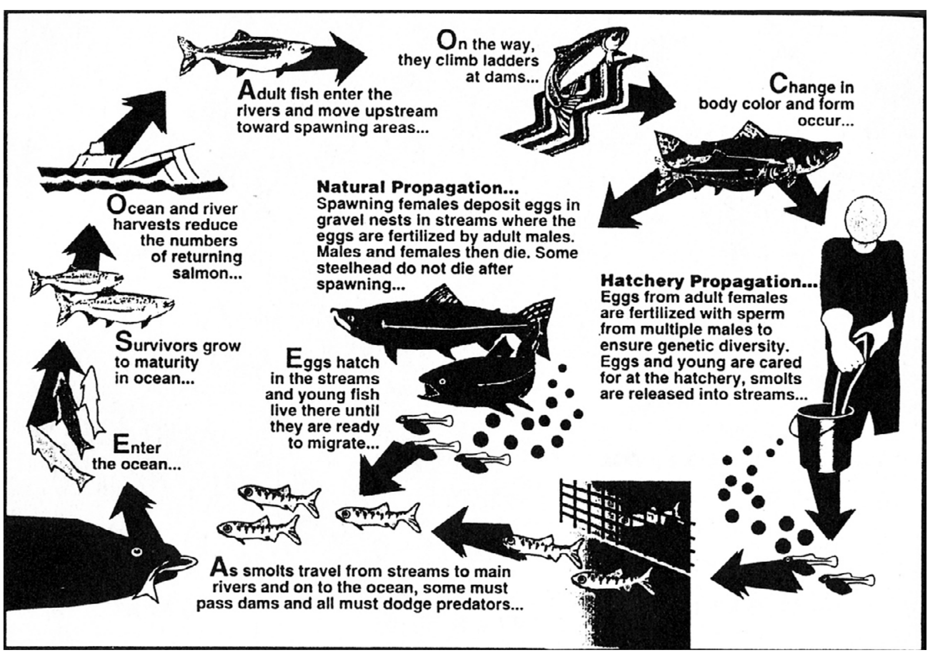
avoiding future costs resulting from water quality decline, deforestation, global warming and other micro- and macro-ecological transformative processes benefits economic as well as environmental interests. Such a full life cycle costing accounts for natural capital as well as financial and social capital.

While the boundaries for this study are broad, this inquiry is narrowed to a few key building-related spheres of influence that represent either a high mitigation potential or for which little primary research has been undertaken:

- generic *site* issues (independent of building location)
- *upstream* material environmental burdens
- building *use* phase impacts
- *downstream* material environmental burdens

To understand the geographic breadth of this study, it is helpful to review the life cycle of salmon. (See Figure 4) In the fall or spring females select sites for spawning in a stream bed, dig crater-shaped depressions in the gravel and deposit pea-sized eggs which can range in number from a few hundred to several thousand. Males then compete to fertilize the eggs, which females subsequently bury and guard. Within a few weeks adults of both genders die near the spawning sites. The eggs develop in the gravel and hatch several months later into larvae, known as alevins, which remain buried until consuming their yolk sac. They then emerge as free-swimming fry, which either begin feeding in the stream or migrate from it. Some species migrate to the sea directly, while others, such as coho, migrate after a year. Young salmon, which are adapted to freshwater, prepare for their new saltwater environment through a complex developmental transformation called smoltification, which involves physiological, biochemical, morphological, and behavioral

Figure 4: Salmon Life Cycle



Source: "Upstream: Salmon and Society in the Pacific Northwest," Committee on Protection and Management of Pacific Northwest Anadromous Salmonids; National Academy Press, Washington, D.C., 1996, p. 22.

changes.[9] Most salmon reach maturity in the ocean and return to the site of their birth to spawn after 2 to 6 years, thus completing the cycle. Some species, such as Kokanee, never migrate to the sea, but reach maturity in freshwater lakes. Not all salmon die after spawning; cutthroat and steelhead migrate back to the sea after spawning, and then return to spawn again after one or more seasons.[10]

In part, the methodology interrelates the life cycles of salmon and buildings - the start of a systems-based approach. The complexity of the salmon issue calls for systems thinking as expressed in the following excerpt from an essay on aquatic biodiversity:

> "There is little point in attempting to conserve particular species without paying attention first to the whole system….The problem that we have is that maintaining the aquatic system is more difficult than the maintenance of, say, a functioning area of forest or grassland as an island of diversity amid a sea of damaged landscape. It is not possible to draw a boundary around a freshwater system, as is frequently done around a patch of terrestrial habitat to preserve it, with reasonable success, at least in the medium term."[11]

In working with the two life cycles - salmon and buildings - we note that while the salmon life cycle is truly a cycle (since salmon can reproduce), the building life cycle generally exists as a linear flow - the loop hasn't been closed. In a spatial sense, the life cycle of buildings, also expressed as the ecological footprint, may have an expansive geographic scope, since the raw materials for many building products can come from all over the planet. Similarly, because salmon move from freshwater streams confined to finite watersheds to the ocean, they are affected by a global flow of resources which complicates the ability to have precision relative to environmental stressors.

Although we acknowledge the footprints of salmon and buildings in global terms, the geographic boundary of this study focuses on the tri-county region - Snohomish, King, and Pierce counties - which corresponds to regional initiatives. The watershed, while different in scale than the *salmonshed* (which we define as fresh water, estuarine, and saline and therefore global) nevertheless is an effective scale for identifying the multiple life cycle building-related stressors: e.g., industrial emissions, total impervious cover, riparian canopy. (See map on following page)

It is fair to say that as with many analyses of salmon, this study lacks scientific certainty. However, we consider it both productive and beneficial to identify building-related strategies, materials, and methods that individually and collectively have the *potential* to enhance the co-existence of human habitat (our buildings) and salmon habitat. This approach is consistent with the Precautionary Principle, adopted at the 1992 United Nations Earth Summit in Rio de Janeiro. (See sidebar for more information on the Precautionary Principle.)

Finally, while the focus of this study is on buildings' contribution to salmon decline, we acknowledge that considering buildings as isolated elements within an ecosystem provides only a slice of what is necessarily a multi-faceted, integrated approach to redefine human settlement patterns. By filling in some of the gaps, this report can contribute to

The Precautionary Principle
adopted at the 1992 United Nations Earth Summit in Rio de Janeiro

In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[12]

Wingspread Statement on the Precautionary Principle
adopted by a diverse group of international scientists, environmental health advocates and academics

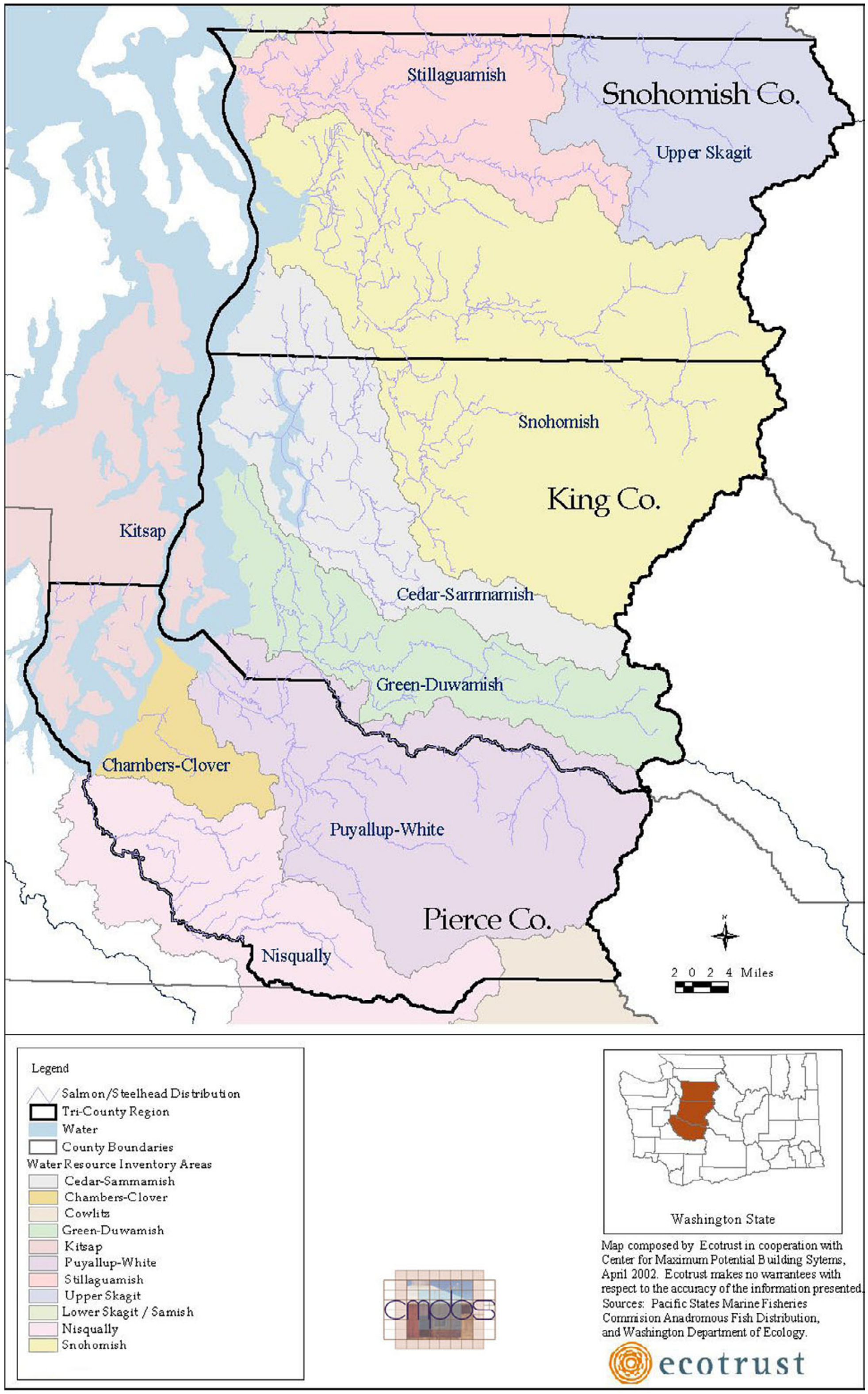
excerpt (full text Appendix B)

"...it is necessary to implement the Precautionary Principle: Where an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."[13]

Application of the Precautionary Principle
salmon strategy

Activities that may result in significant adverse effects on EFH (essential fish habitat) should be avoided where less environmentally harmful alternatives are available. ...Any ...activities (including construction/urbanization, forestry, irrigation water withdrawal, mineral mining, road building and maintenance, sand and gravel mining, wastewater/pollutant discharge, woody debris/structure removal from rivers and estuaries) may eliminate, diminish, or disrupt the functions of salmonid EFH.[14]

Figure 5: Salmon/Steelhead Habitat in the Tri-County Region



that process. However, as much as we draw attention to salmon, we recognize that the health of salmon and their habitats are indicators of the broader objective of the ecological wellbeing of the planet.

Organization of this Report

Methodology -- LEED™

Because LEED™[15] is increasingly serving as the common and defining language for green building, the LEED™ 2.0 categories – *Sustainable Sites*, *Water Efficiency*, *Energy & Atmosphere*, *Materials & Resources*, *Indoor Environmental Quality*, *Innovation & Design Process* – are used as the organizational framework to facilitate integration into existing City of Seattle programs. Thus the report contains a section for each of these six categories, including salmon impacts and salmon-sensitive amended language for existing credits. This builds on Seattle's approach to LEED™ to date, which requires LEED™ Silver certification for all new construction and major renovation projects of 5,000 square feet and greater, and customizes LEED™ to reflect the City's priority concerns and heighten its local relevance.

Within this framework several analyses were undertaken to bring focus to the specific ways that buildings, through their life cycle, affect salmon and their habitat. The area representing the most in-depth study, *Materials and Resources,* was evaluated in part using BaselineGreen™, and five other priority considerations beyond its scope:

- Impervious cover/stormwater runoff (*Sustainable Sites*)
- Salmon-friendly Hydropower, Greenhouse Gas Emissions & Ozone Depleting Compounds (*Energy and Atmosphere*)
- Sand & Gravel mining (*Materials and Resources*)
- Forest & Agrifiber Products (*Materials and Resources*)
- Toxic Chemicals (*Materials and Resources*, *Indoor Environmental Quality*)

BaselineGreen™ – Summary of method

Since approximately half of the effort expended on this study was dedicated to the BaselineGreen™ analysis, it deserves further introduction. Environmental Life Cycle Assessment (LCA) is an approach to the systematic and quantitative study of the upstream, use, and downstream environmental implications of products. Life Cycle Assessments can be conducted using either process-level modeling, or industry/commodity level Input/Output modeling. BaselineGreen™ utilizes the latter approach and limits its scope to only the upstream (or "embodied") environmental consequences of the full set of hundreds of inputs required for a building project. The project input set is fully comprehensive and includes inputs of raw materials, energy, equipment, fabricated products, intermediate products, and services.

By "upstream", we mean all those processes whose outputs are used directly or indirectly to support an activity of interest. Another word for an activity's family of upstream processes is its "supply chain." Theoretically the chain of suppliers is infinite, since all suppliers in turn have their own suppliers. However, we have found from empirical experience that after approximately six to eight supply tiers, the share of total upstream productive output added by additional tiers becomes negligible. This result is in turn caused by the fact that, by definition, the total value of the inputs to an economically viable production process must be less than the value of its output.

The BaselineGreen™ analysis is designed to identify in hierarchical fashion the specific building materials likely to be the largest contributors to salmon and habitat decline relative to extraction and manufacturing processes, and makes extensive use of detailed U.S. Input/Output data from the Bureau of Economic Analysis (BEA) together with federal data on pollution releases by sector from the U.S. Environmental Protection Agency (U.S. EPA) and federal data on fuel-specific energy consumption by sector from the U.S. Department of Energy's Energy Information Administration (EIA). We retained 498 industries from the BEA tables, including government enterprises such as the US Postal Service, and the 488 BEA commodities produced by these industries. For most manufacturing industries, the BEA industries and commodities match the U.S. four-digit Standard Industrial Classifications (SIC), now under the auspices of the North American Industrial Classification System (NAICS). Outside the manufacturing realm, some BEA industries represent aggregations of 4-digit SICs, while other BEA industries are composed of portions of one or more 4-digit SICs.

One of the most significant findings of the BaselineGreen™ study is that the upstream impacts of building materials on salmon in the tri-county region, in quantitative terms, is relatively small, especially as compared to impacts associated with other regional industries. The U.S. EPA Toxic Release Inventory (TRI) data reveal *no* reported toxic releases to land, and relatively small quantity toxic releases to water, the industrial emissions considered to most directly effect salmon. Building-related toxic releases to air were reported, though these represent only 5% of TRI emissions to air of all reporting industries in the tri-county region. While emissions to air may be considered less direct than emissions to land or water, there is concern associated with the atmospheric deposition of air pollutants to land and water, as well as greenhouse gas emissions' contribution to global warming, and ozone-depleting compounds' contribution to stratospheric ozone depletion. In the latter examples, these global-scale outcomes have been found to lead to diminished quality of life for salmon. (See the following section and the *Materials & Resources* section for more details.)

However, as is elaborated in the *Materials & Resources* section, the BaselineGreen™ findings may not tell the whole story. This relates to weaknesses in the TRI data, including the potential for industry under-reporting of emissions, the potential for small quantity generators to be exempted from reporting requirements, and the cumulative, long-term and synergistic effects of multiple chemical releases. What the BaselineGreen™ analysis does well is provide proportional representation of the continuing biochemical environmental stressors to salmon habitat resulting from the upstream impacts linked to the bill of materials associated with generic building design and construction practices, and provides a baseline reflecting national averages. In this way, we are able to compare the performance of regional industries to national industries.

Human-Induced Environmental Burdens

Human-induced environmental (i.e., non-predator/competitor and non-natural event) factors contributing to habitat loss and degradation in all types of habitat– freshwater, estuary, and saline water – can be sorted into two broad categories: water quality and water quantity/rate of flow. The major environmental factors in each of these two categories are summarized in Table 1.

Table 1: Summary of Environmental Factors Contributing to Salmon Habitat Loss and Degradation

Water Quality	Water Quantity/Flow
Toxic releases and sediment contamination	Too much water (stormwater runoff)
Erosion, sedimentation, and turbidity	Too little water
Water temperature fluctuations	Barriers, channels, and diversions

Source: "Factors Affecting Chinook Populations, Background Report" prepared for the City of Seattle by Parametrix Inc., Natural Resources Consultants, Inc., and Cedar River Associates, June 2000.

However, the scope of the BaselineGreen™ analysis is limited, as it now only functions as a partial life cycle tool, lacking some upstream life cycle criteria and certain site-based activities such as erosion.[16] As such, the BaselineGreen™ assessment is narrower than the diverse origins of the many environmental factors discussed above.

As stated above, BaselineGreen™ examines three upstream environmental burdens associated with these inputs – criteria air pollutants[17], greenhouse gases, and toxic releases - using national and state data for industrial facilities (point sources) that annually report these emissions. In its current status, these data are used to portray the typical toxic release inventory and air pollution history of several different industry groups. For this study, we correlated these data to the bill of materials for new retail, office and residential construction sectors, evaluated on four scales: office building (Seattle Justice Center), tri-county region, rest-of-Washington, and rest-of-US.

Toxic releases to water have a direct and significant impact on water quality. Toxic releases to land (or in underground storage) can seep into ground water sources and aquifers and eventually enter lakes, rivers, and streams. Toxic releases to air and criteria air pollutants can return to land and bodies of water through the process of atmospheric deposition. Greenhouse gas emissions can contribute to global warming and subsequently contribute to increases in water temperature and perhaps water level fluctuations.

Erosion, sediment deposition, and turbidity can be a result of logging and quarrying activities. The BaselineGreen™ analysis, as we have stated, does not attempt to examine these links without more development of the model. Additionally, urban development modifications to shorelines, rivers and streams – impervious cover, barriers, channels and dams – are beyond the scope of this work.

Tables 2 and 3 indicate the scale of origin of environmental factors affecting *water quality* and *water quantity*, respectively. The shaded cells indicate the BaselineGreen™ scope of work relative to all of the environmental factors described above: the environmental burdens that originate upstream from manufacturing inputs to buildings. These manufacturing inputs are usually industry groups that can be broken down into identifiable "point source" industrial facilities. In Table 3, note that BaselineGreen™ does not address any environmental factors affecting water *quantity*.

In each of the two tables a check indicates an environmental impact to salmon habitat and the scale at which the impact typically originates. Some are more local impacts such as point source toxic releases to water, some are more state and national in scale such as logging, and some are both such as air pollutants. Toxic releases, air pollutants, and greenhouse gases become urban, regional, and even statewide problems when automobile and truck modes of transportation of goods and services are included. Land use and land cover changes, as well as logging and mining activities, can become national and even international in scale when the watersheds in which the activities are located cross state and national political boundaries (e.g., Washington and British Columbia).

Within the BaselineGreen™ scope, the upstream building-related environmental burdens linked to the above factors are prioritized from most direct to least direct impact on salmon habitat as follows:

- Most direct: Toxic releases to water,
- Toxic releases to land/underground,
- Toxic releases to air,
- Criteria air pollutants,
- Least direct: Greenhouse gases.

As mentioned above, the direct link between toxic releases to water or land and water quality is self-evident. Toxic releases to air and criteria air pollutants are less direct factors since the process of atmospheric deposition must occur to accrue airborne toxics and pollutants on land or in bodies of water. Atmospheric deposition also disperses and dilutes toxics and pollutants over a widespread area. Most of the State of Washington is rated as having low to moderate susceptibility to the process; in fact, documented levels of many

Table 2: Building and Urban Development Associated Environmental Burdens Detrimental to Water Quality Sorted by Origin
(Shaded cells indicate scope of work of the BaselineGreen™ analysis.)

	Environmental Factor	Building and Development Related Issue	Industrial Facility/ IndustryGroup	Urban Scale	Watershed / Regional Scale	State Scale	National Scale	International Scale
Water Quality (Freshwater, Estuary, and Saline Habitats)	Toxic Release Contamination	Toxic releases to water	√	√	√			
		Toxic releases to land/underground	√	√	√			
		Toxic releases to air	√	√	√			
		Air pollutants	√	√	√			
	Water Temperature Changes	Greenhouse gases	√	√	√			
		Impervious cover		√	√			
		Land use and land cover changes		√	√	√	√	√
	Erosion, Sedimen-tation and Turbidity	Impervious cover		√	√			
		Land use and land cover changes		√	√	√	√	√
		Logging and mining			√	√	√	√

Table 3: Building and Urban Development Associated Environmental Burdens Detrimental to Water Quantity Sorted by Origin
(None of these building and development issues is included in the BaselineGreen™ analysis.)

	Environmental Factor	Building and Development Related Issue	Industrial Facility/ Industry Group	Urban Scale	Watershed / Regional Scale	State Scale	National Scale	International Scale
Water Quantity and Flow (Primarily Freshwater and Estuary Habitats)	Too Much Water	Impervious Cover		√	√			
		Dredging, Filling Channelization		√	√			
		Land Use/Land Cover Changes		√	√	√	√	√
		Logging And Mining			√	√	√	√
		Channels and dams	√	√	√			
	Too Little Water	Municipal, Industrial, Agricultural Use	√	√	√			
		Lack of retention	√	√	√			
	Barriers and Diversions	Land Use/Land Cover Changes		√	√	√	√	√
		Dams	√	√	√			

pollutant indicators have not increased over the past 20 to 30 years.[18] Greenhouse gases are considered the least direct environmental factor since many steps and processes leading to increases in water temperatures are involved. Moreover, many other factors contribute to climate changes related to increasing air and water temperatures such as non-point source pollution (automobiles), urban heat islands, and vegetative cover. For example, non-riparian forest removal may have more impact on stream temperatures than the narrow bank of riparian areas.

Beyond the BaselineGreen™ scope, other urban and regional scale building and development activities are linked to the environmental factors contributing to salmon habitat loss and degradation. These include the following:

- Transportation issues (*Sustainable Sites*)
- Land use and land cover changes (*Sustainable Sites*)
- Changes to and loss of wetlands (*Sustainable Sites*)
- Percent impervious cover (*Sustainable Sites*)
- Municipal, industrial, and agricultural water use (*Water Efficiency*)
- Diversions and dams (*Energy and Atmosphere*)
- Logging and quarrying activities (*Materials and Resources*)
- Dredging, filling, and channelization of rivers and streams (*Materials and Resources*)

The first four of these issues are addressed by LEED™, while the remaining issues are addressed, at least in part, within this report.

Recommended Strategies

Beyond BaselineGreen™ findings, the building-related strategies that emerge as most beneficial to salmon are:

- Identify opportunities to reduce impervious cover/stormwater runoff (*Sustainable Sites*)
- Continue adherence to salmon-friendly hydropower, reduce greenhouse gas emissions associated with manufacture of portland cement and steel, and phase-out the use of ozone depleting compounds as cost-competitive alternatives become available (*Energy and Atmosphere*)
- Comply with and monitor NMFS best management practices for all regional sand and gravel extraction and substitution of recycled content/by-product aggregates for virgin stock (*Materials and Resources*)
- Bolster market demand for Forest Stewardship Council (FSC) certified wood products and materials and agrifiber substitutes by specifying them in applications for which they are cost-competitive and provide equal or better performance than non-FSC certified wood products and materials (*Materials and Resources*)
- Consistent with the Seattle City Council's passage of a resolution to reduce the purchase of toxic products on 1 July 2002, phase-out procurement of products that release toxic chemicals through their life cycle, particularly those that are persistent and bioaccumulative, as cost-competitive products of equal or better performance become available (*Materials and Resources, Indoor Environmental Quality*)

LEED™ Based Analysis

SS WE EA MR IEQ ID

The following sections adapt the established LEED™ 2.0 categories to a salmon-focused analysis, with suggestions for revised language, and technical and regulatory information that may have specific bearing on salmon. The primary salmon impacts for each LEED™ category are noted at the beginning of each section, followed by a credit by credit discussion of salmon-friendly recommendations and potential solutions, which are summarized in the Salmon-Friendly LEED™ Overlay (Appendix B). The authors assume LEED™ fluency among readers of this report. For background information, visit the U. S. Green Building Council web site.[19]

While the scope of this report excludes addressing where buildings locate, how buildings are designed and constructed directly affects site issues such as erosion and sedimentation control, impervious cover, and stormwater runoff, each of which relate to stormwater management. Since stormwater affects both water quantity and quality, responsible stormwater management is an essential element for safeguarding salmon habitat with a magnitude likely greater than for any other single category relative to near-term consequences. Sedimentation, pollution, and temperature fluctuations affect water quality, while the amount of total impervious cover area has a large effect on both water quantity and quality. Although many other features of the built environment influence urban stormwater runoff, such as roads and parking lots, buildings and their sites are significant factors.

Impacts to Salmon

The effects of erosion and sedimentation, pollution, temperature fluctuations, and total impervious area have the greatest impacts to salmon.

Erosion & Sedimentation

Soil erosion during construction is a potentially significant source of sedimentation in urban streams. Salmon, steelhead and coastal cutthroat trout are susceptible to sediment pollution because they build their nests in the stream bottom. The eggs, buried one to three feet deep in the gravel redd, rely on a steady flow of clean, cold water to deliver oxygen and remove waste products. During the 60 day period when eggs and alevin are in the gravel, major shifts of the stream bottom can kill them.[20] As the alevin develop into fry, they use up their yolk and must emerge through spaces in the gravel to take up life in the stream. In a literature review, researchers found that increasing levels of fine sediment caused a decrease in salmonid egg and alevin survival. Fines less than 0.85 mm show the highest impact on egg survival but sand sized particles (<6.4mm) may also intrude into the stream bed forming a layer in the stream gravels which sometimes prevents emergence of fry.[21] It has been postulated that because of varying head diameters, chinook salmon are the most susceptible to increased fine sediment, followed by coho salmon, steelhead and cutthroat trout, respectively.[22]

Toxic Pollution

Urban stormwater can carry a range of pollutants including suspended solids, organic materials, hydrocarbons, heavy metals, insecticides, and herbicides (see Table 4). Although not all of these are toxic, urban stormwater runoff is one of the most significant sources of toxic water pollution.[23] Because buildings and associated infrastructure represent a significant percent of total impervious area in an urban environment, they are a source of some of these pollutants.

For example:

- Nutrients such as phosphorous and nitrogen can come from lawn fertilizer runoff, pet excrement, and failed septic systems, which are also a source of bacteria. In a process known as eutrification, excess nutrients in surface waters promote algae growth which depletes oxygen by shading underwater plants;[24]
- Hydrocarbons come from engine oil, gasoline, and diesel fuel which drip from vehicles onto roadways and parking lots;

Table 4: Typical Pollutant Concentrations in Urban Stormwater[28]

Pollutant	Concentration*
Total Suspended Solids	80 mg/l
Total Phosphorous	0.3 mg/l
Total Nitrogen	2.0 mg/l
Total Organic Carbon	12.7 mg/l
Fecal Coliform Bacteria	3600 MPN/ 100 ml^
E. Coli Bacteria	1450 MPN/ 100 ml
Petroleum Hydrocarbons	3.5 mg/l
Cadmium	2 mg/l
Copper	10 mg/l
Lead	18 mg/l
Zinc	140 mg/l
Insecticides	0.1 to 2.0 mg/l
Herbicides	1 to 5 mg/l
Chlorides (winter only)	

*Results compiled from seven studies carried out between 1983 and 1997 by the Center for Watershed Protection for the *Maryland Department of Environment Stormwater Manual*.

^ Bacteria levels measured in “Most Probable Number.”

Table 5: Characterization of Stormwater Pollutants[28]

Pollutant	Description
Suspended Solids	Soil particles and other material blown in from surrounding land, washed in by erosion, or dropped from vehicles. Suspended solids lead to sedimentation which is a direct threat to salmon.
Nutrients	Principally nitrogen and phosphorous. Sources include fertilizer runoff from lawns, pet excrement, and failed septic systems.
Organic Carbon	Also referred to as biochemical oxygen demand (BOD), organic matter washed into surface waters decomposes through bacterial action , robbing the water of oxygen.
Bacteria	High levels of bacteria, including fecal coliform, are regularly found in stormwater. This is the health threat that most commonly closes public swimming areas and shellfish beds.
Hydrocarbons	A wide range of hydrocarbons, including engine oil, gasoline, and diesel fuel, are dripped onto roadways and parking lots. Many of these are toxic to aquatic organisms.
Trace Metals	Trace metals, such as lead, zinc, cadmium, copper, and mercury, are deposited into impervious surfaces from the atmosphere or from automobile tires and fluids. Cadmium and mercury are PBT's and copper is highly toxic to many aquatic organisms.
Pesticides	Pesticide residues remain a serious pollutant in stormwater and are often toxic to aquatic organisms.
Chlorides	Calcium chloride is routinely applied to cold-climate roads in winter for ice control and to dirt roads in summer for dust control.
Trash and Debris	While primarily a visual pollutant, trash is often contaminated with other pollutants.
Thermal Pollution	Asphalt pavements and low slope roofs heat up in the sun, and runoff from these surfaces can warm nearby streams threatening salmon habitat.

- Heavy metals come from vehicles' tires, fluids, and brake linings (in the case of copper);
- Pesticides and chemicals can contaminate runoff from landscapes;
- Asphalt pavements and low slope roofs heat up in the sun, and runoff from these surfaces can warm nearby streams threatening salmon habitat.

Earlier studies by and for the City of Seattle have indicated the presence of hundreds of chemical compounds from streets, highways, and other developed urban areas in stormwater. Several non-point sources were identified including automobiles, leaking septic fields, and household fertilizer use.[25]

Water Temperature

As referenced in Table 5, asphalt pavement and low-slope roofs heat up in the sun, and runoff from these surfaces can warm nearby waterways. As with most tributaries in Seattle's urban and urbanizing regions, the Duwamish Estuary has experienced increased surface water temperatures over the past 20 years. Studies have associated this with factors resulting from urbanization, including increased runoff from impervious surfaces and loss of riparian vegetation.[26] Loss of watershed forest also increases watershed temperatures and may even exceed the impact associated with the loss of riparian shade, as the excerpt from a 1999 report reveals:

"Temperature models show that stream temperatures are more sensitive to air temperature than to shading (Sullivan et al. 1990). The US Fish and Wildlife Service SSTEMP model (Theurer et al. 1984), for example, predicts a 4°C increase in stream temperature for a 4°C air temperature increase (from 19°C to 23°C), while a change in canopy cover from 75% to 0% would cause a 5°C increase (Sullivan et al. 1990). Field measurements by Sullivan et al. (1990) also suggest that air temperature has a stronger proportional influence on stream temperature than does shade.

"Effects of a cut margin on air temperatures in the adjacent stand are well described. Chen et al. (1995), for example, found at sites in western Washington and Oregon that maximum air temperatures at stand margins are elevated 2°C to 16°C relative to interior temperatures, and that the temperature effect generally extends 60 to 120 meters (equivalent to 1 to 2 tree heights) into the old-growth stand. A figure accompanying the paper (Chen et al. 1995, Fig.3) indicates that air temperatures 50 feet from the stand margin have recovered by only about 20%, and that recovery at 100 feet is on the order of 50%. Measurements by Sullivan et al. (1990) also indicate that temperatures at the margins of clearcuts are a minimum of 15% higher (relative to 0°C) than at locations more characteristic of the interior of a stand (Sullivan et al. 1990; the widths of the buffer strips are not noted). These results demonstrate the importance of managing riparian stands to maintain appropriate air temperature regimes if appropriate stream temperature regimes are to be maintained."[27]

The Duwamish provides habitat for salmon during many life cycle stages, including adult migration, juvenile migration and rearing, and as a transition zone for adults and juveniles. Chinook, coho salmon and steelhead and cutthroat trout all require cold water. Although water temperature tolerance varies somewhat between species and between life stages, warm water temperatures can reduce fecundity, decrease egg survival, retard growth of fry and smolts, reduce rearing densities, increase susceptibility to disease, and decrease the ability of young salmon and trout to compete with other species for food and to avoid predation. The National Marine Fisheries System characterized salmonid habitat as "at risk" when spawning temperatures exceed 15.5˚C and rearing temperatures exceed 17.8˚C. As a general condition, it has been recommended that floating weekly maximum water temperatures not exceed 15˚C or that maximum temperatures not exceed 20˚C in Washington State.[29]

Impervious Cover

Since impervious cover area, also referred to as total impervious area (TIA), affects both stormwater quantity and quality, it is a direct determinant of watershed health. Urban areas are more likely to degrade streams than any other type of land use, including agriculture, forestry or range, and result in polluted runoff and altered hydrology,[30] reflecting the high concentration of impervious surfaces including building rooftops, sidewalks, parking lots, roads, gutters, storm drains, and drainage ditches in urban areas. The percentage of total impervious area can lead to starvation of shallow aquifers that provide the base for summer flows (which naturally limit salmon productivity) and, because impervious surfaces increase the amount of evaporation as compared to pervious surfaces, more runoff is produced exacerbating flooding in winter and robbing shallow aquifers that provide baseflow in summers.

In a study of 22 Puget Sound streams, researchers determined total impervious area to be the key index for gauging impacts on urban streams.[31] The first signs of degradation come at about 5% TIA with very little ecological function retained in streams with more than 45% TIA.[32] More specifically, coho populations appeared to be reduced in areas with 10-15% imperviousness. In general, deterioration of instream functions and value begin to occur when impervious surfaces exceed 10% of a subbasin.[33] Streams where setbacks allowed for protected riparian zones benefited from riparian function, such as filtering runoff and providing large woody debris (LWD). In urban streams, researchers found increased chemical runoff, increased flood peaks, loss of LWD and overall stream habitat complexity, increased fine sediment, and decreased diversity and abundance of aquatic insects and other biota.

Dense urbanization can also lead to flooding. Stormwater that runs off from multiple impervious surfaces into receiving streams leads to increased peak discharges, decreased discharge time for runoff to reach the stream, and increased frequency and severity of flooding. Of each of these outcomes, flooding is of particular concern as it reduces refuge space for fish and can scour eggs and young from the gravel.[34] Studies in King County compared hydrologic conditions between forested watersheds vs. fully urbanized watersheds (assuming 40% impervious surface) relative to flooding. Over a 40 year period, forested watersheds were predicted to have seven 5-year flood events with intervals ranging between four and 14 years, while urban watersheds were predicted to have 38 flood events with only a single year without a flood of this magnitude.[35] Roads and paved surfaces in urban areas have been found to effectively double the frequency of hydrologic events capable of mobilizing stream substrates. The resulting increased scour of gravel and cobble in places where salmon eggs, alevins, or fry reside can kill salmon directly, or indirectly increase mortality by carrying them downstream and away from stream cover.[36]

Distinguishing between urban streams and larger bodies of water relative to the effect of stormwater runoff is important. The previous discussion has focused on urban streams where the effects of runoff on water quality and quantity are the greatest. Large bodies of water, such as Lake Washington and the Puget Sound shoreline, apparently have the least susceptibility to many of the environmental factors listed above. The relatively large volume of water in these salmon environments makes them more resilient

Porous Pavement
Brief Description

Porous pavement, first engineered by researchers at the Franklin Institute in Philadelphia in the 1970's, is an asphalt paving mixture with the properties of conventional asphalt, but is constructed using an aggregate mix that minimizes the presence of fine particles, allowing rainfall to drain through the pavement. Under the pavement is a crushed stone storage bed that receives rainfall from the pavement and inflow from other impervious surfaces such as rooftops and driveways.

Beginning in 2001, the Washington Aggregate & Concrete Association (WACA) has partnered with the City of Seattle to develop standards and specifications for permeable paving appropriate for the Seattle region, with existing and prospective demonstration projects underway. According to WACA Executive Director Bruce Chatkin, any soil type including glacial till is applicable for permeable paving with appropriate adjustments to the mix design to accommodate different soil types. Mr. Chatkin foresees a time when surfaces such as subdivision streets, sidewalks, and parking lots will be converted to pervious paving, thereby eliminating stormwater vs. continuing to treat and manage stormwater as occurs today. He acknowledges that to be successful, such a strategy will require changes in maintenance techniques and a systemic overhaul in practices associated with how pavements are designed and constructed.[37]

Table 6: Benefits of Porous Paving
courtesy of Cahill Associates, an environmental consulting firm with over 25 years experience installing porous paving

Environmental	reduces amount of impervious surface from development
	reduces volume of stormwater runoff and peak rate of fine . . .
	reduces discharge of pollutants and improves water quality
	facilitates groundwater recharge to maintain groundwater levels and base flow in streams
	reduces drainage problems associated with stream channelization and sinkholes
Economic	reduces land space consumed by conventional detention facilities
	reduces need for curbs, gutters, inlets, and storm sewers
Aesthetic	Eliminates need for unsightly detention basins, rip-rap channels, etc.
	preserves areas such as woods or open space otherwise affected by detention basin
	eliminates puddling and flooding on parking lots

to short term environmental stresses than small rivers and urban streams. For example, stormwater runoff may temporarily impact a localized area of a lake or shoreline, but the (typically) short duration and dilution of the runoff will likely limit the negative effect on salmon habitat in proximity to the runoff event.

Outside the City of Seattle, particularly in the two surrounding watersheds, the Cedar/Sammamish and the Green/Duwamish, (see Figure 5), all of the environmental factors listed in Table 1 play a role in contributing to salmon habitat loss and degradation. Factors affecting water quality include the presence of contaminants and/or pollutants in some tributaries, sedimentation, and increasing water temperatures (apparently weather induced). Factors affecting water quantity/flow include high and low water level problems associated with uncontrolled stormwater runoff and a large number of flood control structures and diversions that are barriers to salmon migration.

Salmon-Friendly LEED™ Overlay for *Sustainable Sites*

Prerequisite 1: Erosion and Sedimentation Control

RECOMMENDED ACTION:

- **Implement best stormwater management practices.**

Follow practices established in the Washington Department of Ecology in "Stormwater Management Manual for Western Washington", August 2001.

Credit 1: Site Selection

RECOMMENDED ACTION:

- **Avoid construction in riparian areas.**
- **In riparian areas, establish buffer zones.**

In riparian areas, buffer zones should range from 25 feet to 100 feet depending upon slope and stream size. For slopes equal to or greater than 10%, buffer zones should be no less than 50 feet.[38]

Credit 2: Urban Redevelopment

RECOMMENDED ACTION:

- **New construction should not exceed 10% net impervious cover.**
- **Existing buildings should diminish their net impervious cover to approximate the 10% benchmark.**

Along with other researchers, the State of Washington Department of Fish and Wildlife acknowledges that 10% is an impervious cover limit required to ensure ecosystem health; instream functions and value begin to deteriorate when the imperviousness exceeds this value. Since the percentage of imperviousness exceeds 10% in most urban watersheds, existing buildings should be evaluated to determine how to diminish their net imperviousness, and new construction should be designed to comply with no new effective impervious standards in watersheds that exceed 10%.

Credit 3: Brownfield Redevelopment

RECOMMENDED ACTION:

- **Avoid uncontrolled release of hazardous materials from contaminated construction sites.**

Ensure that disturbance of contaminated site does not result in the uncontrolled release of hazardous materials, as with stormwater run-off, particularly in watersheds with salmon habitat. (Note: all watersheds in the tri-county region have salmon habitat.)

Credit 5.1: Reduced Site Disturbance

See benefits of reduced total impervious area identified in Credit 2 above.

Credit 5.2: Reduce Development Footprint

See benefits of reduced total impervious area identified in Credit 2 above

Credit 6: Stormwater Management

RECOMMENDED ACTION:

- **Control sources of contamination.**
- **Minimize amount of stormwater generated.**
- **Remove contaminants from stormwater.**

Responsible stormwater management requires a three-phase strategy: control sources of contamination, minimize amount of stormwater generated, and remove contaminants from stormwater that is generated.[39]

Controlling Sources of Contamination

- Require animal waste collection
- Implement Best Management Practices

Green Roof
Brief Description

Green roofs, or eco-roofs are a living vegetated roofing alternative which cover otherwise impervious roof surfaces with regionally-adapted plant species grown in a permeable soil matrix. Depending on rain intensity and soil depth, green roofs are estimated to reduce runoff by 15% to 90% for a single storm event[40] with the average annual runoff reduction estimated between 50% to 60%.[41] This approach reaps additional benefits including longer roof life, sound attenuation, increased insulation value, absorption of CO_2, production of O_2, and reduced heat island effect.

Green roof costs can range from $11 to $20 per square foot dependent on factors such as roof slope, insulation requirement, building height, special permitting, type of vegetation, and capacity for human habitation. A recent green roof project in Seattle was bid at approximately $15 per square foot, while the green roof installed on the recently completed Jean Vollum Natural Capital Center in Portland, Oregon cost $11 per square foot. Price estimates for a green roof system based on international experience average about $20 per square foot. These prices are two to three times higher than a conventional modified bitumen built-up roof, about $5.50 to $6.00 per square foot.

for hot spots such as car washes, gas stations, and fuel transfer or storage areas (See practices promoted by Seattle Public Utility, Washington Department of Ecology, and the King County Industrial Waste Program (www.ci.seattle.wa.us/util/surfacewater/businessinspect.htm).
- Reduce fertilizer and pesticide use

Generating Less Runoff

(primarily a function of the impervious surface area)
- Reduce impervious surfaces
- Decouple impervious areas
- Eliminate curbs
- Collect rainwater off the roof
- Install porous pavement where appropriate (determine whether soil type is compatible with porous pavement; Seattle's glacial till soils may represent challenges to achieve desired performance)
- Install Green roofs (see sidebar)

Cleaning up the Stormwater that is Generated

LEED™ 2.0 specifies a limit on the total suspended solids and total phosphorous for stormwater runoff in a performance-based requirement. We recommend placing a limit on all pollutants listed in Table 5, and employing mitigation strategies such as structural (dry and wet detention ponds, infiltration basins, infiltration trenches, porous pavement), and proprietary treatment systems that are most cost effectively applied when there is limited available land. Monitoring is an essential element to verify performance relative to the standard, and to prompt appropriate system modifications.

Credit 7: Landscape and Exterior Design to Reduce Heat Islands

RECOMMENDED ACTION:
- **Maximize shading strategies.**
- **Maximize pervious surfaces.**

Pursue shading strategies (natural vegetation and constructed shade structures) to lessen the heat build-up on impervious surfaces; employ green roofs, pervious paving, and rainwater harvesting to lessen stormwater run-off quantity.

WE Water Efficiency

SS WE EA MR IEQ ID

Since all of the LEED™ requirements in this category encourage water conservation, they relate to water *quantity* rather than *quality*. In addition to reducing demand on Seattle's freshwater supplies, water efficiency also reduces electrical demand by reducing pumping requirements and offsetting the energy used to heat water.

Seattle's freshwater supply comes from the rain and snowmelt in two eastern watersheds: the South Fork Tolt River Watershed supplies one third of the water for Seattle's 1.3 million people, while the Cedar River Watershed supplies the balance. Both watersheds comprise large uninhabited areas. The City is responsible for managing not only their hydrology, but also the associated land, forests, and wildlife. According to Seattle Public Utilities' Bruce Flory, in 2001 and 2002 the City provided an average 140 million gallons per day (mgd). In addition to providing a water source, the Cedar River Watershed has a hydro plant, providing 1% of Seattle City Light's electricity supply. As an indicator of Seattle's aggressive water conservation initiatives, SPU's baseline water demand is projected not to exceed 200 million gallons per day in the forecasted time horizon, though these are only estimates and can't account for unforeseen changes in supply and demand.

Impacts to Salmon

Withdrawing freshwater for irrigation, power generation, industrial and municipal uses can result in an array of impacts on salmonid essential fish habitat (EFH), including physical diversion and injury to salmon, impediments to migration, changes in sediment and large woody debris transport and storage, altered flow and temperature regimes, and water level fluctuations. Reduced water levels may result in a higher concentration of pollutants in rivers and streams; these reduced water levels may also effect an aquatic system's biological components including riparian vegetation. As the manager of both the Tolt River and Cedar River watersheds, the City of Seattle must consider these impacts while balancing the freshwater needs of human and salmon populations. Seattle's impressive stewardship is setting the standard for salmon habitat protection and restoration.

In the Cedar River Watershed, several species found downstream of Landsburg, where the City withdraws its water, are either already listed under the Endangered Species Act, are proposed for listing, or are at risk, including coho, chinook, and sockeye salmon, as well as bull and steelhead trout.[42] In response, the City of Seattle has developed the Cedar River Watershed Habitat Conservation Plan (HCP) through which it has made a 50 year commitment to programs designed to provide significant benefits to fish and wildlife. This plan was developed in collaboration with state and federal agencies, with input from tribal biologists and regional scientists, and commits $89 million to improving conditions for fish and other wildlife. For example, $38 million has been allocated "to protect and restore habitats and populations of anadromous fish currently blocked from entry into the municipal watershed by the Landsburg Diversion Dam".[43]

The situation in the Tolt River Watershed is similar, where summer run steelhead trout, coho, and chinook salmon are all potential candidates for endangered species listings. Since none of these species have yet been declared endangered, a habitat conservation plan has not been pursued to date. Instead, the Tolt Fish

Habitat Restoration Group was formed, a partnership comprised of members representing 14 state, federal, county, tribal, environmental, public utility, and academic organizations. This group prioritizes projects based on potential biological benefit, and gives preference to protect and restore critical spawning and rearing habitat in the basin.[44] Projects range from removal of fish passage barriers to continuous temperature measurement in the South Fork Tolt River to monitor the impact of water releases from the reservoir and from the hydropower project.

Salmon Friendly LEED™ Overlay for *Water Efficiency*

The City of Seattle has aggressively pursued water conservation, as demonstrated by Seattle Public Utility's "1% for Conservation" program, designed to reduce demand by 30 million gallons per day by the year 2040. The Utility should be commended for having met the goal of 1% reduction every year since 1980. The authors acknowledge the measures already underway in Seattle and the surrounding region, and encourage building designers, owners, and operators to maximize water reduction schemes according to the LEED™ credits listed below. Look to the U.S. Green Building Council's LEED™ Reference Guide for recommended strategies. As some of these strategies are eligible for utility-funded rebates, building owners, operators and facility managers should check with their local utility to determine eligibility. For example, Seattle Public Utilities offers incentives for beyond-code fixtures such as waterless urinals, which are well-documented to dramatically reduce water use in commercial facilities.

Credit 1: Water Efficient Landscaping

RECOMMENDED ACTION:

- Maximize the use of native plants in landscaping to reduce irrigation requirements.
- Employ greywater and captured rain-water for irrigation.

Credit 2: Innovative Wastewater Technologies

RECOMMENDED ACTION:

- Redirect greywater and captured rainwater to use in toilet flushing.

Credit 3: Water Use Reduction

RECOMMENDED ACTION:

- Install dual-flush toilets and waterless urinals in commercial buildings.

A study conducted by Seattle Public Utilities found that the dual-flush toilet reduced water use by 24% beyond the savings achieved from a 1.6 gallon per flush toilet, while waterless urinals are recognized to dramatically lower water consumption in commercial buildings.

EA Energy and Atmosphere

SS WE EA MR IEQ ID

The quantitative and qualitative aspects of energy supply and its atmospheric consequences appear to affect salmon much as they do people and other life forms. Though less directly than the release of a toxic substance into a body of water, studies indicate that global climate change and stratospheric ozone layer depletion may contribute to salmon decline.

In aggregate, producing electricity has significant environmental burdens, releasing as by-products nearly two-thirds of U.S. sulfur dioxide, one-third of ground-level ozone precursors nitric oxide and nitrogen oxide, and one-third of carbon dioxide emissions. Because more than half of Washington State's electricity is generated by hydroelectric facilities, Washington is relieved of many of the environmental burdens faced by much of the rest of the U.S. However, hydroelectric facilities pose a different set of environmental challenges that potentially affect salmon.[45]

Seattle City Lights' hydro-dominated energy grid reflects the region's historical water abundance, with 94.6% of supply provided by seven hydropower facilities, three of which are owned and operated by the City and located on the Skagit River, a prime habitat for endangered salmon. The remaining 5.4% of energy supply is provided by wind power and natural gas, among other market options. A plant in Oregon provides the portion of energy generated using natural gas, replacing energy formerly supplied by the coal-fired Centralia plant, the second largest sulfur dioxide emission source in the western United States.[46] As a more cost-competitive substitution for hydroelectric than other renewable sources, shifting supply to natural gas will increase the greenhouse gas contribution associated with Seattle's energy grid. An opportunity exists, in the transition to competition, to accelerate the introduction of new, cleaner technologies. Since energy is paid for in both economic and environmental currencies, competition should aim to ensure that costs are decreased in all currencies, rather than shifting costs between the economic and environmental categories. Continuing in its commitment to move away from dependency on nonrenewable energy resources, Seattle City Light began purchasing electricity from the Stateline Wind Project in January 2002. Currently, SCL receives the electricity associated with 50 MW of capacity of the plant. This amount will increase in August 2002 to 100 MW, ramping up to as much as 175 MW in 2004.

Historically, the City of Seattle's commercial energy code has been among the most stringent in the country, with annual goals set to purchase the equivalent of 6-2 aMW of avoided generation through conservation. Typically, these goals, which vary from year to year, have been exceeded. Moving forward, the development of a salmon-friendly energy grid requires attention to both supply and demand. Relative to demand, Seattle is halfway to meeting its 10% electricity reduction goal,[47] while on the supply side, Seattle is pursuing several salmon-friendly energy options in addition to working towards a policy initiative to become greenhouse gas neutral. This resolution, passed by Seattle City Council in April 2000, established "…a long-range goal of meeting the electric needs of Seattle with no net greenhouse gas emissions."[48] The "Earth Day 2000" resolution quoted above was further reinforced by the net zero greenhouse gas emissions resolution, which lists energy conservation and purchasing renewables as preferable to mitigation strategies.[49] In response, Seattle City Light (SCL) developed the Greenhouse Gas Mitigation

Table 7: Low Impact Hydropower Institute (LIHI) Criteria

- river flows
- water quality
- fish passage and protection
- watershed protection
- threatened and endangered species protection
- cultural resource protection
- recreation
- facilities recommended for removal

Program, with a goal to offset the CO2 emissions from its purchase of electricity from the Klamath Cogeneration plant by the end of 2002, and for its entire greenhouse gas footprint in 2003. Moreover, an effort is underway to further diversify the grid through renewable, non-carbon sources such as biomass, geothermal, hydroelectric, solar, wind, and landfill and wastewater treatment methane gas. Pursuing the dual strategy of reducing demand and transitioning to an electrical grid combining low-impact hydro, other renewables such as wind and solar photovoltaics, and cleaner burning natural gas will lessen the impacts associated with more conventional energy generation and assist the City's goal to comply with the Kyoto Protocol.

Impacts to Salmon

The major impacts to salmon for this LEED™ category are hydropower, greenhouse gas emissions, and ozone depletion.

Hydropower and Salmon

Although technically a renewable resource, hydro facilities as conventionally designed and operated are treacherous for salmon. According to researcher Patrick Mazza, 95% of salmon mortality in the Columbia River is linked to dams.[50] Dams can completely block the upstream migration of fish, even if equipped with fish ladders. Moreover, the reservoirs created by dams lack the current needed to guide juvenile salmon to the ocean. This can be critical to fish that have evolved to transform themselves to life in saltwater at a particular time or stage of development. Slower migration to the sea also exposes young salmon to more predators. By slowing down water and creating large lakes, dams can also cause the river's water temperature to rise, which can be fatal to fish. Additionally, dams capture the peak run-off to use later in the year, thus often eliminating the spring freshets that hasten the salmon to the sea, and restrict high winter flows that would normally fill the river, thus enabling adults of winter runs to reach their spawning grounds.[51] At other times, so much water is released at such high velocity that it sweeps fish out of the river before they are ready, and washes away small gravel and sediment below dams. "Pumps and turbines in dams often suck up fish and kill them, and fish that go over the dam spillway often get gas bubble disease from the water's extreme turbulence."[52]

Responding to these breaches, strategies have emerged to lessen hydro-related impacts to salmon and other aquatic species. "Low impact hydro," now adopted by several jurisdictions, is a carefully designed, implemented and evolving refinement to the technology, with specific protocols to ensure compatibility with salmon. Indeed, in August 1998 the Portland, Oregon City Council passed a resolution urging utility companies to offer customers a salmon-friendly power option. According to For the Sake of Salmon's Executive Director, Bill Bradbury, "Portland is the very first city to pass this kind of resolution and take the discussion seriously." The intent of the resolution is to generate hydropower electricity that doesn't harm fish, particularly providing adequate fish-passage.

Seattle's commitment to salmon-friendly hydro extends back several decades, and predates the standardization of salmon-friendly hydro protocols developed by the Low Impact Hydro Institute (LIHI), that certifies hydroelectric power facilities that meet certain criteria (see sidebar). Beginning in 1989, Seattle City Light (SCL) adopted a 'Fish First' strategy focused on the preservation and protection of fisheries resources in the Skagit River basin. Chum, pink, and chinook salmon populations have either increased in abundance or stabilized in the 1990's as a result of this effort. Such improvement stands in stark contrast to other area rivers, many of whose salmon populations continue to dwindle.

In 1991, Seattle City Lights entered into Settlement Agreements with twelve stakeholders as part of project re-licensing. The agreements designate that the Skagit dams regulate water flow to mitigate environmental damage both to salmonids and their habitat. These efforts have bolstered SCL's progress towards protecting salmon since 1981 when dam operations were first modified. Since that time, maximum flows are limited during salmon spawning period, minimum flows are designated during salmon incubation, and large water releases are not allowed when salmon fry are abundant. In 1999, before the Low Impact Hydropower Institute had officially issued its criteria and before it was accepting applications, Seattle City Light prepared a report, based on LIHI draft certification standards from 1997, for the three plants on the Skagit – the Gorge, Diablo and Ross dams (referred to collectively as the Skagit River Hydroelectric Project). The electricity output from these dams, on average, constitutes about 24% of SCL's total electric portfolio. Because all three dams are located upriver from the historical limit of anadromous salmon migrations, they avoid the problems associated with allowing salmon to pass over the dam. While timing did not permit SCL to seek LIHI certification for these dams, the Skagit River Hydroelectric Project meets all of LIHI's requirements and has received third party certification. Indeed, the report was submitted to the Northwest Energy Coalition, Renewables Northwest Project, and the Natural Resources Defense Council for review, and each endorsed it as an environmentally preferred project.[53]

Because the Skagit River Hydroelectric Project meets the LIHI requirements (though has not been officially certified), it fulfills the LEED™ requirement for Green Power (EA Credit 6). Indeed, a credit interpretation for the Seattle Justice Center for EA Credit 6 was approved in Fall 2002.[54]

At least two other variations on the salmon-friendly hydropower theme are underway. As of March 1, 2002, Portland General Electric (PGE) and Pacific Power customers can purchase 100% renewable energy supplied by Green Mountain Energy Company. Those who choose Green Mountain's Salmon-Friendly Plan pay an additional monthly flat fee, a portion of which is donated to the non-profit Pacific Salmon Watershed Fund (PSWF), a 501(c)(3) charitable organization operated by the salmon recovery organization, For the Sake of the Salmon, and is used for salmon habitat restoration. Another supplier, Bonneville Power Administration, generates 15,000 of its 17,000 megawatts by what they term "green hydropower", though just 20 megawatts have received an eco-endorsement by environmental groups like Renewable Northwest and American Rivers.

The South Fork and Cedar Falls plants, representing only about 1.5% of SCL's energy portfolio, meet Green-E requirements as their capacity is less than 30 aMW. The South Fork Settlement Agreement, signed by Seattle City Light in the 1980's as part of the FERC re-licensing process, makes several further commitments to protect and improve salmon habitat affected by that facility. The Habitat Conservation Plan prepared by Seattle Public Utilities for the Cedar River Watershed under the Endangered Species Act will do much to protect drinking water for 1.3 million people and restore habitat for 83 fish species.

Seattle City Light's largest hydropower plant, Boundary, provides about 38% of the utility's energy portfolio. Like the Skagit dams, the Boundary plant is located above the reaches of salmon migrations. Positioned on one of the Pend Oreille, a branch of the Columbia River, the facility minimizes water flow impact to salmonids living downstream using operational criteria developed by the National Marine Fisheries Service for the Federal Columbia River Power System.

Fluctuating the amount of water allowed through the dam in accordance with seasonal river flows can reduce the annual energy available from the Boundary plant by as much as 30 aMW.

Greenhouse Gas Emissions and Global Warming

Much of the current interest in energy efficiency is driven by well established concerns of fossil fuel emissions' contribution to global warming. Studies are beginning to emerge that establish correlation between salmon survival and global warming. Since this will affect both oceans and streams, global warming will impact salmon at all stages of their life cycle. Warming trends in the Pacific Ocean, in part attributed to global warming, have been linked to a drop in salmon population. Researchers suspect that the warmer water results in a stratification such that nutrients are trapped far below the migrating salmon inhabiting the upper ocean.[55] In a draft document prepared by the Northwest Fisheries Science Center, data suggest that "…salmon populations also appear to be affected by variation in ocean conditions associated with short- and long-term climatic fluctuations. …These temperature changes affect phytoplankton production, which in turn affects zooplankton abundance. …"[56] The projected 2^{o} - 4^{o} C increase in ocean surface temperature, combined with anticipated slowing of wind speeds, would affect ocean upwelling whereby waters from the depths rise to the surface, bringing nutrient-rich cold water needed for the salmon's food chain; cold water nutrients feed zooplankton, which feed salmon.

For Washington State, the most dramatic effect of global warming is likely to be hydrological, and therefore a potential threat to the region's freshwater salmon population. In general, increased water temperature makes survival harder for the cold-water adapted salmon. Warmer water during incubation results in premature hatching and increased mortality. Winter floods resulting from unseasonably warm temperatures reduce survivability of young fry. The timing and flow volume of stream discharges, including spring snowmelt that take the salmon downriver, are altered by warming. During upstream migration, higher temperatures and lower volume increases mortality risks of adults going to spawn. However, recent findings that Puget Sound waters are *cooling* adds an additional dimension to the climate change puzzle.[57]

Ozone Depletion

Salmon are vulnerable to increased exposure to ultraviolet radiation, a consequence of stratospheric ozone layer depletion, and are among the most threatened species because their eggs or larvae are in shallow waters in the early spring.[58]

Based on 1999 TRI data, two tri-county building-related manufacturers reported use of Freon 113, an ozone depleting compound slated for a January 1, 1996 phase-out (see Table 8 below). In follow-up calls, General Plastics indicated it no longer uses Freon 113 having converted to 141B, an HCFC scheduled for phase-out in 2015; representatives from Johns Manville have not responded to our phone calls. Freon 113 has an ozone depleting potential of 1, while refrigerant 141B has an ozone depleting potential of 0.11.

Table 8: Tri-county Building Product Manufacturers using Ozone Depleting Chemicals

Facility	Product	Ozone Depleting Compound Used	Alternative
General Plastics Mfg. Co. 4910 Burlington Way Tacoma, WA 98409	Closed cell polyurethane foam board	Freon 113 (claim not to have used for 6-8 yrs); Acknolwedged use of Freon 11	141B, an HCFC with phase-out scheduled for 2015
Johns Manville Intl. 7615 S. 212th St. Kent, WA 98032	Polyisocyanurate roofing insulation	Freon 113	Not identified

Salmon-Friendly LEED™ Overlay for *Energy and Atmosphere*

Most of the prerequisites and requirements in this category are geared toward reducing energy demand, shifting to renewables, and eliminating ozone depleting compounds. EA Prerequisites 1 and 2, along with Credits 1, 3, and 5 are all about reducing demand: designing energy efficiency into the building, and then ensuring the efficient performance of the building at occupancy and for the rest of its life. Credits 2 and 6 require use of renewable energy, while Prerequisite 3 and Credit 4 advocate the use of non-ozone depleting compounds. The City of Seattle has one of the nation's most rigorous energy efficiency programs. The authors acknowledge the energy efficiency measures and incentives in Seattle and the surrounding region, and encourage building designers, owners, and operators to maximize strategies to reduce energy demand based on the LEED™ credits listed below. As some of these strategies are eligible for utility-funded rebates, building owners, operators and facility managers should check with their local utility to determine eligibility.

EA Prerequisite 3: CFC Reduction

RECOMMENDED ACTION:

- City of Seattle's procurement policies should enforce the Montreal Protocol regarding CFC products.
- City of Seattle should work with regional governments to pursue strategies to accelerate the phase-out of all ozone depleting compounds, including HCFCs, used by regional manufacturers.

City of Seattle's procurement policies should enforce the Montreal Protocol and require documentation to ensure that all products purchased by the City comply with the prescribed phase-out. Additionally, the City should work with regional governments to pursue strategies to accelerate the phase-out of all ozone depleting compounds, including HCFCs, used by regional manufacturers. This recognizes salmon's vulnerability to increased exposure to ultraviolet radiation, a consequence of stratospheric ozone layer depletion caused by the release of CFCs, HCFCs and halons.

EA Credit 1: Optimize Energy Performance

RECOMMENDED ACTION:

- Meet and exceed the ASHRAE 90.1, 1999 standard, as well as the City of Seattle's energy performance requirements

EA Credit 2: Renewable Energy

RECOMMENDED ACTION:

- Identify non-hydro renewable sources such as wind, biomass, and photovoltaics, as well as salmon-friendly hydro.

EA Credit 3: Additional Commissioning

RECOMMENDED ACTION:

- Ensure that plumbing systems are included in recommissioning manual scope.

EA Credit 4: Ozone Depletion

RECOMMENDED ACTION:

- Balance reduction of ozone depleting compounds with global warming potential.
- Specify non-ozone depleting refrigerants and fire suppressants.

Balance reduction of ozone depleting compounds with global warming potential, recognizing that both are contributing factors to salmon decline;

specify non-ozone depleting refrigerants and fire suppressants as available and balanced with global warming potential. (See also EA Prerequisite 2, above.)

Seattle City Light Green Power Option
Brief Description

Beginning January 1, 2002, in response to a state legislative mandate, Seattle City Light is offering customers a green power option. In the"short term, this will be generated by wind and other non-hydro renewable sources, and thus has the potential to be Green-E compliant.[59]

Since Seattle City Light has a monopoly on Seattle's electricity market, there is a unique opportunity to shift the market towards renewables. As mentioned above, SCL has already begun to enter the non-hydro renewable market with the launch of the Stateline Wind Project in January 2002. The 1996 report issued by the Comprehensive Review of the Northwest Energy System, a forum convened by the Northwest governors, provided the following recommendation to utilities in this regard: "modest investments in the following three areas: renewable research and development; direct application of renewables, such as geothermal district heating and solar hot water; and renewable resource "market transformation," including financing packages and other measures to develop the renewables market". The report speculates that in the short run, renewables will be at a competitive disadvantage in the wholesale market where cost is the primary criterion. However, in the longer term, renewables are expected to have an edge because of lower emissions and, more specifically, no greenhouse gas emissions.

EA Credit 6: Green Power

RECOMMENDED ACTION:

- Comply with the Green-E Renewable Electricity Program for certification of renewable energy sources.

This LEED™ credit requires compliance with the Green-E Renewable Electricity Program for certification of renewable energy sources. As of this writing, no generating facility in Washington State has been certified through the Green-E program, though the Bonneville Environmental Foundation's Green Tag program, available to any Washington resident, has been Green-E rated. Hydroelectric power plants are eligible for Green-E certification if they produce 30 aMW or less, or if the plant has also been certified by the Low-Impact Hydropower Institute. (See sidebar on page 36 for LIHI criteria.) Beginning in 2002, Green-E equivalent certification can also be sought for plants over 30 aMW that become LIHI certified. Note that some green energy sources may comply with the Green-E requirements even without formal certification. Refer to the sidebar on this page for a description of the Green Power Option offered by Seattle City Light.

MR Materials and Resources

SS WE EA MR IEQ ID

The focus of this section is threefold: (1) the *upstream* environmental burdens associated with the manufacture of building materials; (2) *substitution strategies* to accelerate reliance on targeted recycled-content and rapidly renewable resources as replacements for virgin materials; (3) *downstream* burdens associated with disposal of particular materials.

Impacts to Salmon

Studies have established that salmon are vulnerable to numerous bio-chemical consequences of manufacturing.

For example:

- **Embodied energy** (the energy associated with the extraction, processing and transportation phases of the life cycle prior to use) has a direct relationship to global warming potential, which may result in increased temperatures in the streams, rivers and oceans inhabited by salmon at various stages in their life cycle. It is important to note that there is uncertainty on the region-specific impacts associated with global warming in the Pacific Northwest, with some studies indicating that it could result in the cooling vs. warming of the Puget Sound;

- **Extractive industries**, including sand, gravel and forest resources, can alter ecosystems thus transforming the habitat conditions essential for salmon survival

- **Refrigerants and blowing agents** release CFCs and HCFCs, known to deteriorate the stratospheric ozone layer resulting in increased exposure to ultraviolet radiation. Although the internationally-sanctioned Montreal Protocol has banned CFCs and established a timetable for the phase-out of HCFCs, there is evidence that both are still in use by building-related manufacturers in the Seattle region;

- **Chemically-intensive manufacturing**, such as with paint, plastics, and treated wood can result in chemical releases to water, land, and air that can directly and indirectly contaminate salmon habitats.

This section will address these issues relative to steel and concrete manufacturing, general mining, wood and agrifiber products, and toxic chemicals.

Embodied Energy

Three of Seattle City Lights' six top electrical customers are building-related industries: Birmingham Steel (#1), Ash Grove Cement (#5) and Lafarge Cement (#6), each of which have been exploring and adopting modifications to enhance operational efficiencies. Because Seattle's electrical grid is currently dominated by hydro-generation, these industries' associated CO2 emissions, or global warming potential (GWP), is substantially less than for industries that rely on coal- and natural gas-based electrical generation. However, because of projected supply shifts, the future is likely to see a more diverse electrical generation grid in the northwest, characterized by decreasing hydro and/or shift to low-impact hydro and other renewables, and increasing percentages of natural gas and potentially coal.[60]

Birmingham Steel operates a scrap-based mini-mill that produces steel and steel products, including steel reinforcing bar and rounds, squares, flats, angles, channel and strip sold to fabricators. As Seattle City Light's largest customer with consumption greater than 250,000 mwh per year, efforts have been

Impact of Mining on Water Quality
excerpt

"The mining industry recognizes the probability that mining has degraded the quality of America's surface waters more than any other component of the environment…. Between 1961 and 1975, for example, a conservatively estimated 10 million fish were killed by mining-related water pollution in the U.S. (U.S. EPA 1979)."[61]

underway to enhance Birmingham's energy efficiency, with benefits accruing to both the company (lower operating costs) and the City (lower demand). Sparked by the rolling black-outs of 2001 that imperiled electrical customers all along the west coast, Birmingham struck a deal with the City of Seattle in December 2001 providing for lower electricity rates in exchange for Birmingham's agreement to temporarily forego power on short notice during diminished generation capacity.

Seattle's two cement kilns, Ash Grove Cement and Lafarge Cement – the only ones in Washington State – also represent significant share of Seattle's electricity demand. For further discussion, see the Cement section in *Materials & Resources*, below.

Mining in General

Mining in Washington State includes carbonate, coal, metals, stone, sand and gravel. (See sidebar) The extent to which mining activities affect salmon essential fish habitat (EFH) reflects the type, extent, and location of the activities, and the extraction method: surface or underground mining. While underground mining can contribute to salmon decline, surface mining is considered to have greater potential to affect aquatic ecosystems.[62] For example,

Figure 5: Washington State Mining Operations by County
Number of Sites with Active WashingtonState Department of Natural Resources (DNR) Reclamation Permits

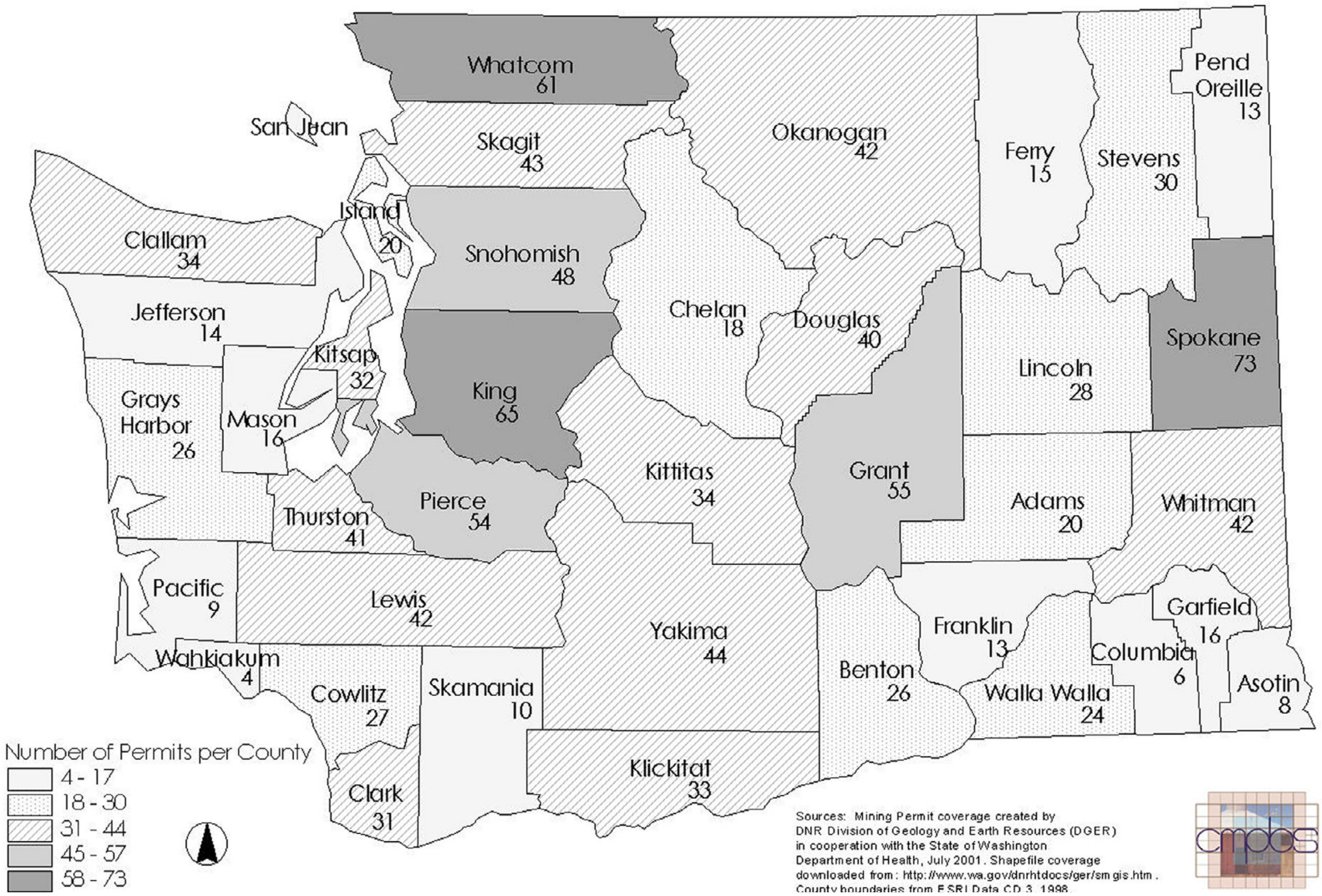
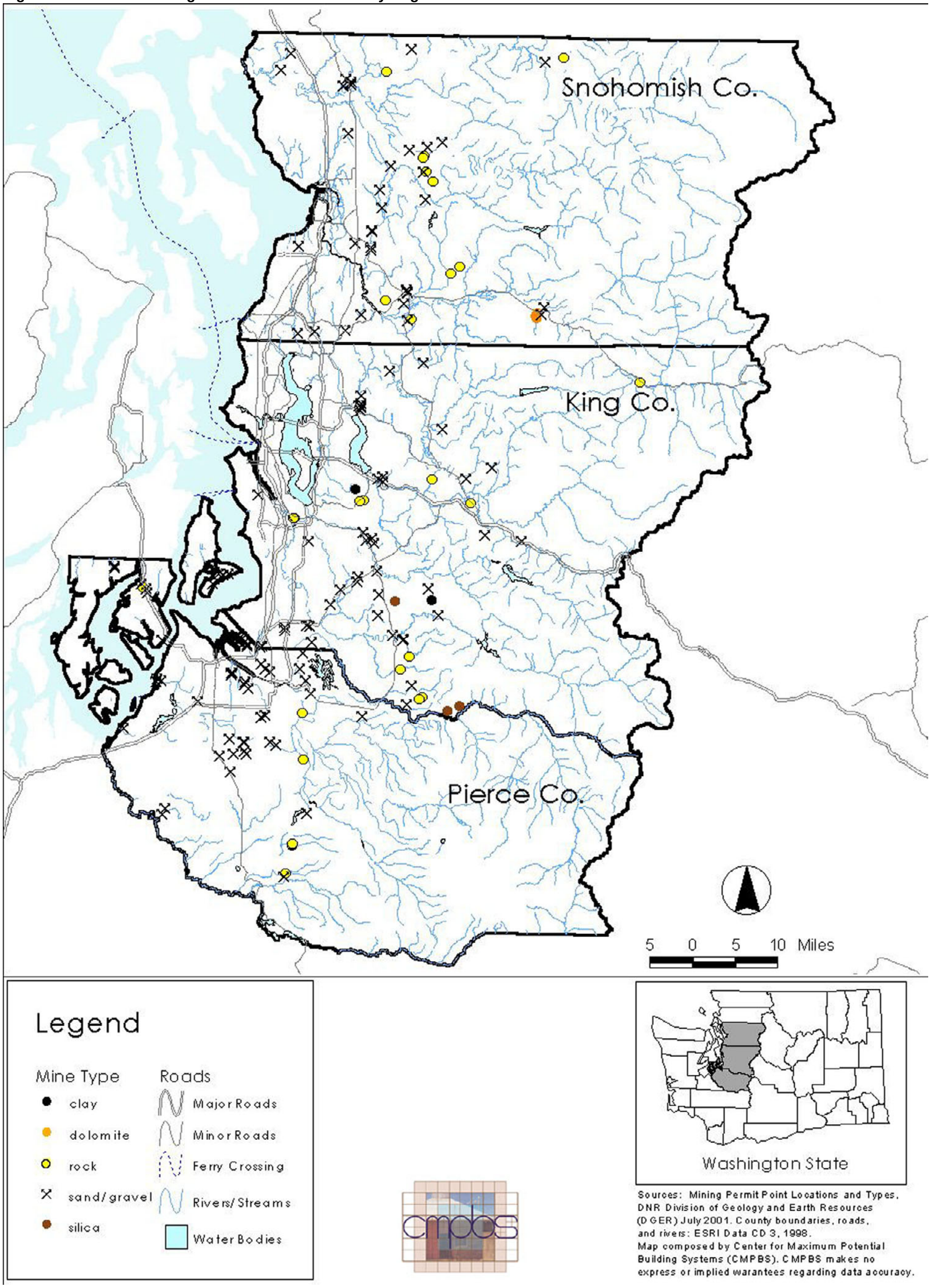


Figure 6: Permitted Mining Facilities in the Tri-County Region



"…surface mining typically increases sediment delivery much more per unit of disturbed area than other activities because of the level of disruption of soils, topography, and vegetation. Erosion from surface mining and spoils may be one of the greatest threats to salmonid habitats in the western US."[63] The Surface Mining Control and Reclamation Act (SMCRA) of 1977 states that mining activities must be performed so as to "minimize disturbances and adverse impacts of the operation on fish, wildlife and related environmental values, and achieve enhancement of such resources where practicable."[64] In addition, Washington Department of Ecology's 1994 Shoreline Management Guidebook recommends local governments encourage miners "to locate activities outside the shoreline jurisdiction", interpreted as 200 feet from the floodway, or off the 100-year floodplain.[65]

Though hard rock (underground) mines operate from five to 15 years or until the minerals are depleted, contamination that happens as a consequence of mining activities can continue for hundreds or thousands of years after mining operations have ceased.[66] These sites can produce heavy-metal effluent affecting water quality and pose risks to fish and other resident biological communities. Based on epidemiological principles, strong correlation has been established between heightened levels of heavy metals and the condition of invertebrate communities in impacted creeks. Specifically, according to the University of Washington's Center for Streamside Studies, "Elevated concentrations of cadmium, copper, selenium, and zinc in streamwater and sediments have reduced species diversity and abundance in these aquatic communities. Contaminated headwater streams are significant hazards to the environment and threaten juvenile salmonids, including bull trout, native steelhead, and chinook salmon…".[67]

Although Washington Aggregate & Concrete Association's Bruce Chatkin considers existing regulatory structure sufficient, the authors' communications with government representatives revealed inconsistent enforcement of protective measures. With significant increased demand projected for sand and gravel,[68] monitoring and verification of compliance with these standards should be ensured.

Concrete: Portland Cement, Sand, and Gravel

Comprised of about 11% portland cement, 41% gravel or crushed stone, 26% sand (fine aggregate), 6% air and 16% water, concrete is one of the most widely used materials in contemporary construction. Concrete's durability, low maintenance, and high mass characteristics make it well-suited for both residential and commercial applications. For example, about 230 tons of sand and gravel and related products are used to construct an average 2,000 square foot residence in Washington.[69] Depending on how and where these raw materials are sourced, extracted, and manufactured, the level of environmental impact can vary. The greatest environmental impact for portland cement comes from the manufacturing process, while the greatest impact for sand and gravel comes from the extraction process.

Portland Cement

Portland cement is manufactured from a source of calcium, such as limestone, a source of silicon, such as sand or clay, and small amounts of bauxite, iron ore, and gypsum.[70] The primary manufacturing process occurs in a large rotary kiln which reaches a temperature of 2700º F. This high temperature process is the reason that cement manufacturers are some of Seattle City Light's largest customers. Both of Washington State's two cement kilns, Ash Grove and Lafarge, are located in Seattle on the Duwamish Waterway. In addition to electricity purchased from Seattle City Light, both plants are permitted to burn a variety of other fuels to support their operations, primarily coal and petroleum coke, with significantly smaller percentages of other permissible fuels such as tire derived fuel (tdf) and natural gas.

Worldwide production of portland cement accounts for 7-10% of CO_2 emissions and a proportionate contribution to global warming. Because of the 50% CO_2 contribution associated with calcination, even cement plants that rely on electricity generated by hydropower (as is the case with the Seattle facilities) still have significant CO_2 emissions, though less than industry averages. [71]

Of Seattle's two portland cement facilities, Ash Grove is the largest producer and the most efficient, having converted from a "wet" process to a "dry" process with the opening of their new plant in 1992. The dry process has several advantages, two of which are particularly relevant to salmon: water consumption and emissions.

Water Consumption: The dry process significantly lessens water use and discharge with all wastewater flowing to the City's sanitary sewer system. Lafarge is curbing their fresh water demand by participating in a Seattle Public Utilities-sponsored reuse project that will direct industrial, process, and stormwater to the cement plant for reuse in their cement manufacturing process. The projected water savings, yet to be realized as of this writing, should reach about 6.2 million gallons per year.[72]

Energy Intensity: The dry process requires less energy per unit of output than the wet process (about 8.3 tons / mWh for Ash Grove vs. 9.2 tons / mWh for Lafarge.

Emissions: Although the Lafarge plant produces more cement per megawatt-hour of electricity consumed, it produces more CO_2 per ton of cement than the Ash Grove plant because of the combustion of other fuels in the manufacturing process. Thus, the Lafarge plant makes a greater contribution to global warming per unit product by about 1%. In each of the emissions categories measured by Puget Sound Clean Air Agency, except for carbon monoxide, levels for Ash Grove were less than for Lafarge, even with a higher level of output. The higher carbon monoxide emissions may be a function of the dry vs. wet process, one area where that process does not yield a measurable benefit.[73]

Sand and Gravel Aggregates

Washington State's construction activities consume nearly 80 million tons of sand, gravel and crushed rock products each year, or the equivalent of about 15 tons of aggregate per person per year. The State's abundant aggregate resources, representing the fifth largest supply in the U.S., result from glacial activity that occurred 15,000 to 18,000 years ago. Indeed, sand and gravel represent Washington's most valuable production mineral commodity.[74]

Aggregates are heavy and expensive to transport. With transportation representing 45% of their cost, about 20-25 cents per mile per ton, there are compelling economic incentives to locate supply sources close to the point of use. Reflecting transportation's impact on pricing, the Washington Aggregate & Concrete Association estimates that aggregates are most commonly used within a 25 to 35 mile radius of origin.[75] This puts a tremendous burden on resources closely located to areas experiencing high levels of construction activity, especially when those sources are coincident with salmon habitat. Recognizing that mining activities can have severe consequences on fish and other wildlife habitat, there is general guidance for large gravel mines to be located in uplands away from the river valley floors; less desired is for mining to be located on

Table 9: Gravel extraction methods	
Wet-pit mining	extracts sand and gravel from seasonally exposed stream gravel bars below the water table;
Dry-pit mining	extracts sand and gravel from exposed bars and ephemeral streambeds excavated by bulldozers, scrapers, and loaders;
Bar scalping or skimming	removes the tops of river gravel bars without excavating below the summer water (common practice);
Excavation of floodplain and river terrace deposits	adjacent to an active or former channel.

terraces and the inactive flood plain, or above the 100-year flood plain. In Washington, mining upland deposits is considered to eliminate the potential for stream capture or river avulsion, and to improve likelihood of successful long-term reclamation.[76]

Between 1970 and 1991, about one-sixth of Washington's gravel production was removed from riverine sources and located on flood plains and active gravel bars.[77] Despite claims that gravel extraction can be beneficial for salmon, there is broad consensus that it does not result in any general ecosystem benefits, with specific impacts reflecting the method and location of the extraction activities. Indeed, numerous policy directives clearly establish the conflict between gravel extraction and salmon survival, whether the mining activity occurs near an essential salmon habitat (ESH) or some distance away. See Table 9 for a discussion of gravel extraction methods.

NMFS National Gravel Extraction Policy

In 1996, the National Marine Fisheries Service (NMFS), a division of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), issued the "NMFS National Gravel Extraction Policy". The report describes its purpose as providing: "…general policy, procedures, and recommendations of NMFS's National Habitat Program pertaining to any gravel extraction projects within or near current or historic anadromous fish habitat….The intent of the Gravel Policy is to strengthen NMFS efforts in conserving anadromous fish habitat and to foster consistency at the national level, while maintaining regional flexibility….The Gravel Policy is designed to be robust in its protection of anadromous fishes and their habitats."[78]

Key findings of the NMFS Gravel Policy include:

- A national policy on gravel extraction is necessary because extraction in and near anadromous fish streams causes many adverse impacts to fishes and their habitats;

- Gravel extraction operations should not interfere with anadromous fish migration, spawning, or rearing, nor should they be allowed within, upstream, or downstream of anadromous fish spawning grounds;

- Extracting gravel from within or near a stream bed directly impacts a stream's physical habitat parameters by altering the flow patterns resulting from modifying the river bed and increasing suspended sediments. These changes result in reduced fish populations in the disturbed area, replacement of one species by another, replacement of one age group by another, or a shift in the species and age distributions.

Other sediment-related concerns include:

- Resuspended sediments may contain heavy metals, pesticides, herbicides and other chemicals that can be toxic to salmon and their prey;[79]

- Sedimentation may be a delayed impact because gravel removal typically occurs at low flow when the stream has the least capacity to transport the fines out of the system;

- Fine sediments are detrimental to incubating fish eggs and may also inhibit larval, juvenile and adult behavior, migration, or spawning;

- Siltation, substrate disturbances and increased turbidity also affect invertebrate food sources of anadromous fishes.

- Extraction of bed material that exceeds natural replenishment by upstream transport causes bed degradation, reducing the amount of usable anadromous spawning habitat. Mechanical disturbance of spawning beds may result in high mortality rates of eggs and alevins;

• Bed degradation changes the morphology of the channel, potentially exposing the fish to higher temperatures, lower dissolved oxygen, increased predation compared to fish in the main channel, desiccation if the area dries out, and freezing;

• Gravel bar skimming significantly impacts aquatic habitat, thus increasing the susceptibility of downstream salmon redds (nests) to deposition of displaced, surplus alluvial material resulting in egg suffocation or suppressed salmon fry emergence; upstream redds are vulnerable to regressive erosion.

Additional impacts to salmon associated with the extraction of sand and gravel include:

• Decreased nutrients from loss of floodplain connection and riparian vegetation;

• Removal or disturbance of instream roughness elements during gravel extraction activities negatively affects both quality and quantity of anadramous fish habitat. For example, the removal of large woody debris, which helps provide critical freshwater habitat, results in an immediate decline in salmonid abundance;

• Stockpiles and overburden left in the floodplain can alter channel hydraulics during high flows, potentially blocking or entrapping fish and increasing downstream sedimentation;

• Herbicides used to clear vegetation may be used in riparian areas where they may enter water bodies. Exposure to herbicides can have lethal and sublethal effects on salmonids, aquatic invertebrates, aquatic vegetation, as well as target and non-target riparian vegetation;[80]

Included in a list of indirect sources of water pollution affecting salmon habitat are gravel and rock crushing operations, characterized as carrying oil and other hydrocarbons, heavy metals, sediment and other pathogens. The introduction of these pollutants can be lethal to salmon, or have long term chronic impacts that impair their survival.[81]

As the map in Figure 6 (page 43) illustrates, there is an abundance of sand and gravel activity in the tri-county region, accounting for almost 9,000 acres. In 1999, recognizing the potential conflict between mining and habitat protection, House Bill 1284 was proposed to fund a study of sand, gravel, and rock resource mining and its impact on salmon habitat and urban development. Current evaluations predict that existing mines will be unable to fulfill future demand for sand, gravel or rock. The study would identify environmentally sound sand, gravel and rock deposits.

Though the bill was not passed, it identifies a recommended course of action:

• Evaluate impacts of sand and gravel excavation in floodplains on spawning and rearing habitat of salmonid and freshwater species;

• Recommend whether additional controls are needed for sand and gravel extraction in floodplains to protect fish resources;

• Evaluate the expected life of known and designated sand and gravel deposits within an economically viable transport distance from major urban areas;

• Evaluate current sand, gravel, and rock consumption and projected sand, gravel and rock consumption trends for the next 50 years;

• Evaluate alternative sources of aggregate supply including recycling, reuse, conservation opportunities, and quarried rock;

• Recommend to local governments on mineral resource designation standards to protect known deposits of sand, rock, and gravel to meet projected supply needs.

With an estimated cost of $50,000, we recommend that the City of Seattle consider pursuing the elements of this study as outlined in the proposed legislation, perhaps in collaboration with other regional jurisdictions.

Wood and Agrifiber Products

In general, about 55% of wood cut for non-fuel purposes is used in buildings.[82] Some researchers contend there is no inherent conflict between salmon and forests: "Waters in forested lands of western North America are major producers of anadromous salmon and trout….Areas that produce both timber and salmonids coincide over much of western North America, and the increasing public demand for both of these resources create frequent management conflicts. *Under most circumstances, both timber and fish can be successfully managed in the same watershed if measures to protect water quality and fish habitat are carefully coordinated with timber management operations."*[83] (emphasis added) A literature review revealed numerous aspects of forest management impact salmon, such as timber harvests, roads, and the use of fertilizers and pesticides.

Change in the distribution and abundance of large woody debris (lwd) - logs greater than 51cm[84] - in streams constitute one of the most significant impacts. Harvesting practices can reduce the amount and size of lwd vs. that in nonharvested areas. This is important as the presence of lwd in streams is considered a fundamental component of creating and maintaining salmon habitat. Large woody debris contributes to the formation of pools (significant for both juvenile and adult salmon) and other important rearing areas, control of sediment and organic matter storage, and modification of water quality. In addition, lwd results in biological activities including blockages of fish migration, protection from predators and high streamflow, and maintenance of organic matter processing sites within the benthic community. Also, lwd creates falls and riffles that mix oxygen and water, aerating the water.[85]

Roads associated with forestry in particular, and in general, also contribute to habitat decline, increasing sediment delivered to streams through mass wasting and surface erosion. This can elevate the level of fine sediments in spawning gravels and fill substrate interstices that provide habitat for aquatic invertebrates. "*Poor road location, construction, and maintenance, as well as inadequate culverts result in forest roads contributing more sediment to nearby streams than any other forest activity".* (emphasis added) "On a per unit basis, mass wasting events associated with forest roads produce 26-34 times the volume of sediment as undisturbed forests."[86] Washington State's experience in this regard is alarming: "In Washington State, the number of large, deep pools in National Forest streams has decreased by as much as 58% due to sedimentation and loss of pool-forming structures such as boulders and large wood."[87]

Profound changes in channel morphology, light, temperature, and flow regimes are associated with timber harvests. Removing riparian canopy reduces shading and increases the amount of solar radiation reaching the streams, resulting in higher maximum stream temperatures and increased daily stream temperature fluctuations, with even a 1-2ºC increase affecting spawning and incubation. In addition, fertilizers, herbicides, and insecticides commonly used in forestry can be toxic to salmon directly if they enter surface waters, or may alter a stream's primary and secondary production, affecting the amount and type of food available to salmon.

LEED™ recognizes the Forest Stewardship Council (FSC) as the only approved certification entity for determining the environmental integrity of wood products through the chain of custody (from forest to manufacturer). With the release of the Forest Stewardship Council's Pacific Coast Regional Standards (PCRS), currently in draft form (see sidebar), FSC provides specific recognition of the unique characteristics of forested lands in Washington, Oregon and California. The PCRS report cites significant remnants of primary old growth redwood and fir forests still standing; the intention of the standards is to protect them, recognizing that these intact forests are significant to maintain ecosystem processes such as refugia for fish, especially salmonids, and other wildlife.

Correspondence with Robert Hrubes, Senior Vice President, Scientific Certification Systems, one of the FSC-accredited certifiers, yielded pertinent information specific to the Forest Stewardship Council and salmon. All the following questions were posed by the authors, and all answers were provided by Mr. Hrubes:

Q: Does FSC-certified wood provide protection for salmon?
A: "FSC certification is designed to recognize forest management that is environmentally responsible, socially beneficial and economically viable. This implies a balancing of competing, multi-dimensional considerations. So I suppose it is therefore true that it does not entail "optimal" protections for salmonids, if you are defining "optimal" as uni-dimensional protection of salmonids without consideration of other environmental, social and economic tradeoffs. The same would hold for "optimal" protection for spotted owls, marbled murrelet, or any other single wildlife species. Not to mention indigenous people or local citizens....But such a conclusion would beg the question: with respect to assuring protection of salmonid habitat, what other certification system is superior to FSC? The clear answer is that there is no superior alternative."'

Q: If the City of Seattle required all wood used in City projects to be FSC certified, would they be right to assume that the forest practices employed through the chain of custody are protective of salmon and their habitat?
A: "The answer is clearly yes, especially relative to wood associated with any other extant certification program."
Q: How should the FSC certification be modified to address salmon protection?
A: "Endangered species protection is expressly addressed in the context of FSC certification criteria. Could the standards be stronger with respect to salmonids? Yes, but certification criteria certainly aren't chopped liver with respect to watercourse management issues/salmonid protection in their present form."

Based on these responses, the LEED™ provision for specifying FSC-certified wood provides safeguards for salmon protection.

Agrifiber

Given the magnitude of wood use in buildings, particularly in the residential sector, salmon-friendly substitution strategies should be pursued. In addition to FSC-certified wood, agricultural by-products are a rapidly renewable resource that can be substituted for many wood-based products. About 60 million tons of wheat are generated in the U.S. each year,[89] with Washington State ranking third in U.S. total wheat production, producing on average seven percent of the nation's wheat crop. Five Washington State counties are among the top ten wheat producing counties in the U.S., including Whitman County at number one and Lincoln County at number two.[90] Despite the abundance of wheat straw, a by-product of wheat harvest, no manufacturer of straw-based building materials is located in Washington.[91]

The beneficial use of biomass, such as the production of wheat straw board,

Forest Stewardship Council's Pacific Coast Regional Standards (PCRS)
brief description

In general, the PCRS rules "...require management to maintain and restore forest structures, functions, and processes; and to maintain biodiversity at many levels, natural soil characteristics, and hydrological characteristics, at both stand and landscape levels."[88]

Salmon-Safe Certification Guidelines
Brief Description

The Salmon-Safe Certification Guidelines are designed to ensure that farm management practices utilize Best Management Practices (BMPs) to avoid harm, and where appropriate, enhance and restore the health of stream ecosystems. To avoid adverse impacts to salmonid stream ecosystem health, farm operations must address the principal forms of impact:

- Introduction into streams of sediment, energy (temperature) or chemicals from surface of sub-surface runoff;
- Elimination/reduction of riparian vegetation that serves as filters for chemicals and sediment in runoff, provides shade and cover along streams, and supports diverse communities of organisms, including those key to aquatic food chains;
- Direct alteration or disruption of in-stream habitat, stream banks, and streamside conditions through purposeful practices such as bank armoring, redirecting the course of streams, building dams, or inadvertent impacts resulting from excessive, poorly designed or inadequately maintained stream crossings; Alteration of stream flow regimes through stream water diversions or excessive groundwater pumping.

The procedures and evaluation standards have been implemented at more than 70 farms, orchards, vineyards, and dairies, and are continually refined based upon consultation with key stakeholders and pertinent experts.

(Excerpted from DRAFT Salmon-Safe™ Farm Management Certification Program: Field Assessor's Guidelines 4.0, Salmon-Safe Inc., June 2002, www.salmonsafe.org)

can have a positive impact on salmon. Since it provides a substitute for wood-based products such as particleboard and medium density fiberboard, it diminishes the load on forests. Even better, wheat straw derived from crops certified through the Salmon-Safe Farm Management Certification Program ensure that the wheat was grown in a manner protective of salmon.

Just as important, beneficial use of wheat straw offsets the environmental burdens associated with burning agricultural residue. The gases produced by biomass burning, including carbon dioxide and methane, and particulates, are all environmentally significant. Both carbon dioxide and methane are greenhouse gases, while combustion particulates affect the global radiation budget and climate. According to an article in *Environmental Science and Technology*, biomass burning accounts for 26% of net global carbon dioxide production,10% of global methane production, 7% of global particulate matter production and 39% of organic carbon particulate production.[92] It affects the reflectivity and emissivity of the Earth's surface as well as the hydrological cycle by changing rates of land evaporation and water runoff. For these reasons, biomass burning is a significant driver of global climate change.

Toxic Chemicals

Although LEED™ addresses the use of toxic substances only with respect to indoor air quality (IAQ), the life cycle analysis approach includes the toxic releases associated with *all* phases of a material's life cycle, not just the use phase. From this perspective, toxics fall within the context of LEED™'*Materials & Resources*.

The simplest synonym for a toxic is a poison, something capable of causing injury or death, especially by chemical means. Toxic emissions to air, land, and water include compounds such as pesticides, heavy metals, petroleum products, and by-products of industrial activities. In certain environments, these compounds can be acutely toxic or can cause chronic or sublethal effects; they also can bioaccumulate in food chains.

Estuarine food chains are extremely complex and sensitive to alterations in the physical and chemical range of stresses. Loss or disruption of one element can have a cascading effect on species' presence and productivity. As with any form of pollution, the rule of thumb - 'the dose is the poison'- holds true for permissible levels of chemical contamination and nutrients in salmon habitats. According to "Nonfishing Activities Affecting Salmon Habitat", a properly functioning habitat can accommodate low levels of chemical contamination and no excess nutrients. A habitat is considered "at risk" when there are moderate levels of chemical contamination and some excess nutrients. A habitat is "not properly functioning" 'when there are high levels of chemical contamination and excess nutrients.[93]

Both the Puget Sound and the Duwamish Waterway are salmon habitats impacted by toxic chemicals, with the chum, coho and chinook the predominate salmon species passing through the Puget Sound estuaries as they move from fresh to salt water. While only living in the estuarine environment for part of their life cycle, studies document that the contamination in those environments adversely affects salmon health. Research concentrates primarily on juvenile chinook salmon because they most depend on estuaries for their food, stay there the longest of the three species, are representative of all five salmon species in the juvenile stage, and experience rapid physiological change and growth which potentially increases their vulnerability to chemical pollution.

In the April 2001 EPA Fact Sheet, "Update: National Listing of Fish and Wildlife Advisories," the Puget Sound is listed as one of the 20 National Estuary Program (NEP) sites, and as one of the 14

National Estuarine Research Reserve Systems (NERRS) sites. According to this fact sheet, in 2000 there was a general fish consumption advisory for Puget Sound due to PCBs, dioxins, and mercury, while specific Puget Sound embayments were subject to advisories for the following pollutants: creosote, pentachlorophenol, volatile organic compounds (VOCs), tetrachloroethylene, arsenic, metals (unspecified), vinyl chloride, polyaromatic hydrocarbons (PAHs), polynuclear aromatics, and pesticides (unspecified).

Based on studies conducted by the National Oceanic and Atmospheric Administration's Environmental Conservation Division (ECD), diet is the salmon's primary source of exposure to toxic contaminants. In the study, researchers found significantly higher levels of aromatic hydrocarbons (AHs) and PCBs in the stomach of salmon that passed through an urban estuary (Duwamish Waterway) vs. those that passed through a non-urban reference site (Nisqually River).[94] These data corroborate findings from an earlier study undertaken by the National Marine Fisheries Service which also found elevated levels of AHs and PCBs in salmon migrating through the heavily polluted Duwamish and Puyallup waterways than from other sites. Moreover, these salmon were found to have heightened levels of an enzyme activity that results in toxins binding to DNA, thought to be an early stage of carcinogenesis.[95]

Persistent Bioaccumulative Toxins

The pollutants referenced in the aforementioned Puget Sound fish advisory, PCBs, dioxins, and mercury, are all *persistent bioaccumulative toxins* (PBTs),[96] a class of chemicals gaining increased recognition. These chemicals build up in salmon as well as humans - species positioned near the top of their respective food chains - increasing the incidence of effects such as chemical modification of DNA and alteration of immune functions. As numerous recent public policy initiatives indicate, PBT phase-out and elimination is increasingly being viewed as fundamental to achieve environmental and human health. Indeed, on 1 July 2002 the Seattle City Council passed a resolution to reduce the City's purchase and use of products that contain persistent bioaccumulative toxics, or that result in the release of PBTs during their manufacture (such as PVC). See sidebar for a description of PBTs.

Building related industries that release discharges into the Duwamish Waterway, characterized by some as the most polluted estuary in Puget Sound, include cement processors and municipal sewage treatment plants.[98] However, this finding contradicts the BaselineGreen™ analysis that found direct building-related releases to water only from three wood treatment facilities, one in Pierce County and two in Clark County. This finding is also not corroborated by conversations with officials at both plants who claim no direct releases to surface waters, although they do release to the municipal wastewater utility. While as of this writing neither Seattle cement kiln burns hazardous waste as a fuel source, both burn tires and other wastes that could emit PBTs.

Determining the risk to salmon associated with PBTs is important to establish. In a paper presented at the 1999 American Fisheries Society Forum on Contaminants in Fish, "Tribal Technical Issues in Risk Reduction Through Fish Advisories"[99] the authors address risk characterization, and offer several equations to guide decisions concerning risks to specific fish populations. For example, the equation "risk = exposure x toxicity x sensitivity" provides flexibility to acknowledge the unique sensitivities of particular populations (species) to specific chemicals. Another equation is designed to capture the cascading effects between human health, ecological health, ecological injury, economic impacts and cultural impairment: "health risk to an

Persistent Bioaccumulative Toxins
Brief Description

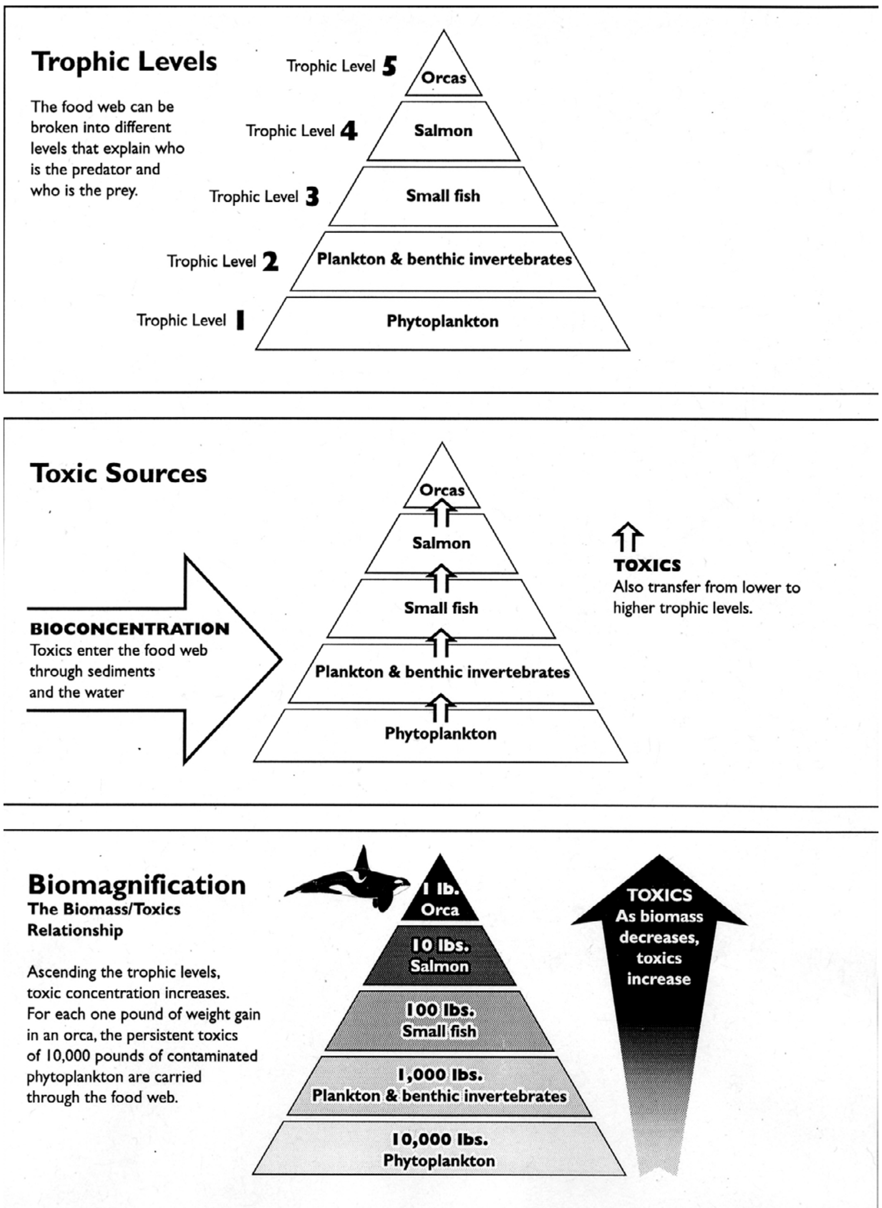
"These chemical contaminants accumulate in the tissues of aquatic organisms at concentrations many times higher than concentrations in the water. These chemical contaminants also persist for relatively long periods in sediments where bottom-dwelling animals can accumulate and pass them up the food chain to fish... Concentrations of these contaminants in the tissues of aquatic organisms may increase at each level of the food chain. As a result, top predators in a food chain...may have concentrations of these chemicals in their tissues that may be a million times higher than the concentrations in the water. Mercury, PCBs, chlordane, dioxins, and DDT...were at least partly responsible for 99% of all fish consumption advisories in effect in 2000."[97]

individual = health effects + *a*(ecological risk) + *b*(economic risk) + *c*(cultural risk)." They do not accept temporal discounting, instead positing that "…risk must be summed for as long as the material remains intrinsically hazardous, remains in the environment, or for as long as the impact (including mutations) persist in the population."[100] Thus, while not explicitly referencing persistent bioaccumulative toxins, they implicitly acknowledge the necessity to address them as a class of chemicals requiring special accommodation, as is underway with Washington State's PBT initiative. It is also important to note that the paper addresses uncertainty, and identifies the Precautionary Principle as a decision-making approach to be used when there is uncertainty and as a complement to risk assessment. (See Precautionary Principle sidebar above)

Reflecting their persistence, bioaccumulation, and toxicity, the federal government and many state governments, including Washington and the City of Seattle (as previously mentioned), have launched policies and programs intended to result in the elimination and phase-out of human-induced PBTs in the environment. This prioritization of PBTs amongst domestic policymakers at the local, state and national scales underscores the importance of these initiatives. While there are differences in the individual PBT chemical lists developed by varying regulatory and environmental organizations, there is consistency with some chemicals on each list. (The December 2001 Washington Department of Ecology's "Washington PBT Working List: Summary Report" identifies 25 priority chemicals and chemical groups.) Among the consistently identified PBTs are cadmium, dioxins and furans, lead, and mercury, each of which have correlation to specific building materials and products manufactured today. (Another priority PBT chemical, PCB, has been phased out though it persists in the environment.) See Table 10 for a list of PBTs commonly associated with building materials.

The State of Washington recently authorized $800,000 towards a PBT strategy designed to eliminate PBTs from the State, with a priority on pesticides (Aldrin/ Dieldrin, Chlordane, DDT, Toxaphene), by-products (benzo(a)pyrene, dioxins and furans, PCBs), hexachloro-benzene, and

Figure 7: PBTs in the Food Chain



Source: "Toxics in the Food Web," People for Puget Sound. www.pugetsound.org/toxicfoodweb/default.html mercury, with dioxins, furans, and mercury having specific links to building materials. In their most recent PBT listing, Washington State identified mercury as the priority PBT chemical. Buildings potentially contribute to upstream, use, and downstream life cycle phase mercury releases through the use of fluorescent bulbs (both tubes & compact fluorescents), high intensity discharge (HID) lamps, paint and electrical switches. Reflecting a recent ruling from the Washington State Department of Ecology, fluorescent lamps are generally considered a "Universal Waste" and require disposition at a lamp recycler or permitted hazardous waste disposal company. Although crushed lamps are allowed at many recycling operations, keeping lamps intact helps to ensure that the mercury is contained until properly processed at a recovery or disposal facility. Just as important, procurement of fluorescent bulbs should specify lowest available mercury; indeed, several manufacturers are diversifying their product lines to offer low-mercury bulbs reflecting concern about mercury's toxicity. Such stringent recycling and procurement policies are especially important as fluorescent bulbs are gaining greater market share, particularly with increased percentages in the residential market due to their long bulb life and reduced energy consumption.

The City of Seattle will be providing specific guidance for its residential customers regarding appropriate disposition of compact fluorescent bulbs, encouraging them to deposit the bulbs at a free Household Hazardous Waste site.[101] More information is available at 206/296-4692.

Seattle City Council's passage in 2002 of a Persistent Bioaccumulative Toxics resolution acknowledges the importance of establishing comprehensive procurement and disposal policies to ensure that mercury does not enter the waste stream or is accidentally released. It is important to note, as well, that all manufacturers of fluorescent bulbs have not actually reduced the actual quantity of mercury in their bulbs but instead have added materials to their bulbs to reduce the amount of leaching. Other potential sources of mercury releases are thermostats and switches. For new purchases, specify mercury-free thermostats and switches (note that Oregon has instituted a ban on mercury thermostat installation) and, prior to building demolition or renovation, ensure that HVAC systems are assessed for mercury containing switches and thermostats and divert these from the construction/demolition waste stream to an appropriate recycling facility.

In 1993 U.S. EPA researchers began studying the effects of dioxins, specifically 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD), on aquatic life, and determined exposure to be extremely damaging. While toxicity test results found that aquatic organisms' exposure to TCDD was not toxic during acute test periods of 24 to 96 hours, studies found that the exposure results in delayed adverse effects in days, weeks and months following. However, there continues to be uncertainty as to the species' sensitivity distribution within fish, and effects on reproduction associated with chronic exposure.[102] Recent data indicate that the Ash Grove cement plant emitted .454 +206 grams /year of dioxin in 2000, while the Lafarge plant emitted about 2 grams/year,[103] with the difference in emissions reflecting the fuels burned in the respective plants.

Another PBT, dioxin, is released during the life cycle of polyvinyl chloride (PVC). According to a 2000 study by researcher Joe Thornton, Ph.D., PVC is responsible for more dioxin formation through its life cycle than any other single product, reflecting the high percentage of chlorine in its chemical composition. Seventy-five percent of PVC plastic is used in building-related applications such as piping, flooring, wallcoverings, roofing, and exterior siding.[104] While not manufactured in Washington State, PVC, like other products that release persistent

Table 10: Persistent Bioaccumulative Toxins (PBTs) Commonly Associated with Building Materials

Cadmium	used as a stabilizer in rigid polyvinyl chloride and paints
Dioxins & furans	emitted from cement kilns, secondary copper manufacture, & by-products of vinyl chloride monomer
Lead	used as a stabilizer in rigid polyvinyl chloride, and manufactured into roof flashing, & terne & copper roofing materials
Mercury	used in fluorescent light tubes, high intensity discharge (HID) lamps, paint, and electrical switches

Table 11: Distinguishing between harmful by-products of PVC[105]

Persistence	substance resists natural degradation, builds up over time in the environment, and can be distributed globally on currents of wind and water. Many of the by-products of the PVC lifecycle are now ubiquitous global pollutants, found not only in industrialized regions but in the planet's most remote ecosystems. Absolutely every species on Earth is now exposed to these substances.
Bioaccumulation	a substance is fat-soluble and therefore builds up in living tissues. Most bioaccumulative substances, including many formed during the PVC lifecycle, magnify as they move up the food chain, reaching concentrations in species high on the food chain millions of times greater than their levels in the ambient environment.
Toxicity	the by-products of the vinyl lifecycle have been shown to cause a range of health hazards, in some cases at extremely low doses. These include cancer, disruption of the endocrine system, reproductive impairment, impaired child development and birth defects, neurotoxicity (damage to the brain or its function), and suppression of the immune system.

Table 12: 1999 Washington State Building-Related Industries Reported Toxic Releases to Water

Manu-facturer	Co.	Pro-duct	Chem-ical(s)	Tot. Rele-ases (lbs)
Cascade Pole & Lumber	Pierce	Treated Wood	Creosotes	10
Allweather Wood Treaters	Clark	Treated Wood	Chromium Compounds Arsenic Copper	12 10 7
Exterior Wood, Inc.	Clark	Treated Wood	Chromium Compounds Arsenic Copper Compounds	12 12 7

bioaccumulative toxics (PBTs) during some stage of their life cycle, could be a trigger for altering the chemistry of salmon. This phenomenon reflects the three qualities that define PBTs – *persistence, bioaccumulative, and toxic*. According to the Global Network of Environment and Technology, "PBT pollutants pose regulatory and environmental challenges because they easily move between air, water, and land, and cross boundaries of programs, geography, and generations."[106] Thornton's study identifies the by-products of the vinyl lifecycle to be of great concern because many of their components are persistent, bioaccumulative, and toxic. (See Table 11)

Lead is another persistent bioaccumulative toxin of concern. Although it has been largely eliminated from paint products and gasoline sold in the U.S., lead continues to be used in roofing applications, including in terne roofing and, more commonly, as roof flashing. While little attention has been directed to its elimination in building materials in the U.S., beginning in December 2002 Denmark will ban the use of lead flashing in new buildings, citing studies that "…have proved that lead leaching from building flashings is the chief source of lead in wastewater and wastewater sludge."[107]

Acknowledging the significant deleterious impacts of PBTs on public and environmental health, governments have begun to establish policies and programs to transition towards PBT elimination. A June 28, 2000 letter from former Seattle Mayor Paul Schell encouraged Washington Department of Ecology's adoption of a "strong (PBT) strategy and to direct the necessary resources toward its implementation." Schell further noted, "The persistent and bioaccumulative nature of these chemicals requires aggressive steps to protect Washington's environment for this and future generations…".

BaselineGreen™ Results

In this section, we summarize findings of the BaselineGreen™ analysis which focuses on the upstream portion of the life cycle of building materials, recognizing that what happens in the course of extracting, manufacturing, and transporting building materials can impact salmon. The full BaselineGreen™ report is in Appendix A.

Earlier in this report, upstream building-related environmental burdens affecting salmon habitat were prioritized from most direct to least direct impact:

Most direct:

- Toxic releases to water,
- Toxic releases to land/ underground,
- Toxic releases to air,
- Criteria air pollutants,

Least direct:

- Greenhouse gas emissions.

For each of these five emissions, the BaselineGreen™ analysis yielded these findings:

- Toxic releases to water: Compared to other industries such as paper manufacturing, building-related industrial toxic releases to water reported in 1999 were relatively small. This is true for both the tri-county region and the rest of the State of Washington, for which there was a reported total of 70 pounds of toxic releases to water from three wood treatment facilities. The single facility in the tri-county region discharged 10 pounds of creosotes to water, while two other facilities in Clark County discharged 60 pounds of chromium compounds, arsenic, and copper compounds (the primary constituents in CCA-treated wood, now slated for a U.S. EPA promulgated phase-out by December 2003). These reported toxic releases to water are in addition to unreported toxic releases to water at the same facility, resulting from polluted stormwater run-off contaminated by treated wood stored on an unprotected outside site.[108] To put this in perspective of total industry toxic releases to water, a single paper manufacturing facility in the tri-county region released over 500,000 pounds of toxic chemicals to water in 1999. (See Table 12)

- Toxic releases to land: With the exception of waste disposal, building related industrial toxic releases to land reported in 1999 were zero. This is true for both the tri-county region and the rest of the State of Washington.

- Toxic releases to air: Compared to other industries, building related industrial toxic releases to air in 1999 were relatively small. The percentage of statewide reported toxic releases to air that can be attributed to building related industries is less than 5% of the total. (See Table 13)

- Criteria air pollutants: With one exception – cement - building-related industrial criteria air pollutant releases in 1999 were relatively small. The cement industry accounts for a fairly large share of all types of criteria air pollutant emissions in the tri-county region.

- Greenhouse gas emissions: Emissions of CO2 associated with the manufacture of cement (SIC code 3241) and fabricated steel products (SIC code 3441) account for a substantial portion of greenhouse gas emissions (GHGs) in the tri-county region and possibly a large portion of GHGs in the rest of the State of Washington. Two cement plants in the tri-county region account for approximately 1 million tons of CO2 emissions per year. The CO2 emission total for Birmingham Steel is about 53,000 tons per year.[109]

In summary, the BaselineGreen™ analysis revealed a small quantity of *direct* links between upstream environmental burdens associated with the manufacture of building materials and products and environmental factors detrimental to salmon habitat. For the most direct environmental burden, toxic releases to water, three building-related industries reported releases in 1999. For the second most direct burden, toxic releases to land, no building-related industries reported releases in 1999.

It appears that, as the links between upstream environmental burdens and salmon habitat become more *indirect*, the role of building-related industries becomes more significant. Several building

Table 13: 1999 Tri-County Building-Related Industries Reported Toxic Releases to Air

Manufacturer	County	Product	Chemical(s)	Total Releases (in pounds)
American Millwork	King	Millwork	Toluene Methyl ethyl ketone Methyl isobutyl ketone	154,000 146,000 59,000
Girard Custom Coaters	Pierce	Lumber & Wood products	Toluene	72,681
Newcastle Brick Plant	King	Brick & Structural Clay Tile	Hydrofluoric acid	52,110
Johns Manville Intl	King	Plastic Foam	1,1-Dichloro-1-fluoroethane (an ozone depleting compound) Chlorodifluoromethane Diisocyanates	39,243 4,724 49
Tiz's Door Sales	Snohomish	Millwork	Toluene	28,748
Lianga Pacific Inc.	Pierce	Millwork	Xylene	11,630
Northlake Cabinet Corp.	King	Wood kitchen cabinets	Toluene	11,179
Canyon Creek Cabinets	Snohomish	Wood kitchen cabinets	Methanol	10,973
Cascade Pole & Lumber Co.	Pierce	Wood preserving	Creosote	1,805
Birmingham Steel	King	Steel	Zinc compounds Manganese compounds Lead compounds Nickel compounds	21,827 2,201 1,646 17
Haworth/Lunstead Ops.	King	Wood Office Furniture	Methanol Toluene	11,947 12,200

related industries reported toxic releases to air, for example. However, the building industry share of annual releases is relatively small as compared to other industries, accounting for only about 5% of total toxic air releases in 1999.

Similarly, for criteria air pollutants, several building-related industries reported emissions, but the total was relatively small compared to other industries. The one exception in the tri-county region is the cement industry, which accounts for a large share of local air pollutants.

As mentioned earlier, the impact of criteria air pollutants on salmon habitat is indirect. The pollutants must return to land and water via atmospheric deposition. Airshed patterns and monitoring of several sites in western Washington indicate that the area is not susceptible to atmospheric deposition. Additionally, air pollution associated with a building may be much greater during its "use" stage due to energy consumption over a building's lifetime.

Similarly, for criteria air pollutants, several building-related industries reported emissions, but the total was relatively small compared to other industries. The one exception in the tri-county region is the cement industry, which accounts for a relatively large share of local air pollutants.

Related to global climate change, also an indirect factor affecting salmon habitat, the effect of upstream building-related industrial greenhouse gas emissions is similar to that of air pollutants. Again the one exception is the cement industry which likely accounts for a relatively large share of local upstream greenhouse gas (GHGs) emissions. Upstream GHGs, however, are relatively small compared to energy consumption during the use stage (occupancy) of a building over its lifetime and to other sources of GHGs (e.g., the transportation sector).

There are, however, several caveats that should be acknowledged qualifying the above findings:

- The Toxic Release Inventory (TRI) data used for BaselineGreen™ relies on industry-generated reports. It is possible that some releases may be unreported or under-reported;

- Establishing direct cause-effect links between specific stressors and salmon is difficult. Scores of studies and scientific reports reference uncertainties associated with definitive declarations of what are contributing factors to salmon decline;

- The qualitative dimension of persistent bioaccumulative toxins (PBTs) as a class of chemicals may not be adequately represented by the way toxic release data are currently reported. Because toxic releases are only reported by quantity, the reporting may not reveal the degree of toxicity associated with small quantities of some chemicals. Beginning in the reporting year 2000, the U.S. EPA has added dioxin and other persistent bioaccumulative toxins to its TRI list of chemicals, with lowered reporting thresholds for certain PBT chemicals. Most PBT chemicals will be reportable at thresholds of ten pounds or 100 pounds manufactured, processed, or otherwise used.

While there are only a few building-related industries reporting toxic releases to water, there are releases to air of both greenhouse gases (principally CO_2) and toxic chemicals. Both of these may result in indirect impacts on salmon: in the case of CO_2 releases, the consequent climate change is associated with rising global temperatures; in the case of toxic releases to air, these chemicals disperse and may eventually fall to the ground, impacting land and water quality. Because of the more distributive nature of air releases than water releases, the point source relative to proximity to habitat is of diminished importance, particularly when these releases are PBTs.

These results point to other possible building-related activities as having a more significant impact on salmon habitats in the region, several of which are detailed elsewhere in this report, and below.

Upstream in the life cycle of buildings, impacts from resource extraction, such as erosion and sedimentation from logging and mining, can be substantial. BaselineGreen™ is not structured to inventory and map regional erosion and sedimentation related to upstream building activities. Additionally, there are supply chain activities that may have environmental impacts other than the three environmental burden indicators mentioned above. Besides erosion and sedimentation, those impacts include loss of vegetation, other changes in land cover, and fertilizer, pesticide, and herbicide use.

A prime example of this is the stormwater release from Cascade Pole & Lumber, located in Tacoma, a facility that treats poles, lumber, and decking. Because the treated wood products are stored in an unprotected outdoor yard, storm events will likely result in the discharge of arsenic, chromium, copper, and pentachlorophenol (penta) into the Puyallup River, host to three runs of chinook salmon listed in the Endangered Species Act, as well as one run of listed bull trout.[110] Penta, a powerful insecticide and a PBT, is often contaminated with dioxin, and has been banned in 26 countries including Germany, Egypt, India, Indonesia, and Korea. Since this industrial pollution is associated with stormwater rather than a continuous discharge, it does not show up in the BaselineGreen™ analysis. And, because this toxic release to water comes from runoff, it also could be classified as a release to land.

Given these conclusions, the following recommendations are made as salmon-friendly policies and practices. These recommendations follow the format outlined in LEED™ 2.0"*Materials and Resources*. However, because the BaselineGreen™ methodology is based on a life cycle assessment (LCA) approach to assessing environmental impacts, in some cases the recommended practices are different than LEED™. These differences will be discussed under the appropriate LEED™ Credits below.

Salmon-Friendly LEED™ Overlay for *Materials and Resources*

Prerequisite 1: Storage and Collection of Recyclables

RECOMMENDED ACTION:

- Ensure that mercury-containing bulbs are properly stored to prevent breakage and potential for release of mercury.

Credit 1: Building Reuse

RECOMMENDED ACTION:

- Maximize reuse of major portions of existing buildings, such as the structure and shell.

Reusing large portions of existing structures reduces the need for newly manufactured building materials and products. As described in the three BaselineGreen™ analyses reviewed in this report, every manufactured building material and product is associated with some form of upstream environmental burden. Reusing major portions of existing buildings, such as the structure or shell, can minimize or even avoid some of these burdens.

Credit 2: Construction Waste Management

RECOMMENDED ACTION:

- Recover and recycle construction and demolition debris.

Recovering construction and demolition debris and recycling it into new products can lessen the environmental burdens associated with manufacturing with virgin materials, particularly when the materials are recycled in the region.

Credit 3: Resource Reuse

RECOMMENDED ACTION:

- Maximize reuse of salvaged or refurbished materials and products from existing buildings.
- Maximize use of industrial byproducts like fly ash.

Specifying salvaged or refurbished materials can reduce the need for newly manufactured building materials and products. Similar to building reuse, using recovered materials and products from existing buildings, such as beams, columns, flooring, doors, and windows can lessen or even avoid upstream environmental burdens.

An LCA approach to assessing environmental burdens reveals that many industrial processes produce usable by-products that are not technically post-industrial or post-consumer recyclables. They are used as processing agents or are physically different than the material or product being manufactured. Unlike recycled or scrap materials, many by-products do not require further processing before being used in the manufacture of another material or product. Fly ash and slag are examples. Under the topic *Resource Reuse* therefore, BaselineGreen™ recommends the inclusion of by-product materials.

Credit 4: Recycled Content

RECOMMENDED ACTION:

- Substitute recycled content materials and products for processed virgin materials.

Recycled content materials and products reduce negative environmental impacts associated with the extraction of new raw materials. Processing of virgin materials consumes both energy and resources and is usually associated with some form of upstream environmental burden. Processing with recycled content feedstocks will eliminate impacts associated with raw material extraction, but may result in manufacturing-related emissions of concern. For example, as Table 13 (page 55) shows, Seattle's Birmingham Steel, a scrap-based steel mill, has air emissions including 1,646 pounds of lead compounds based on 1999 U.S. EPA Toxic Release Inventory data.[111]

Recycled content substitutes for portland cement relieve the significant CO2 emissions associated with the manufacture of portland cement. High volume coal-derived fly ash concrete mixes should be evaluated for efficacy (both cost and performance) for all concrete applications, with a provision to assess the chemical composition of the fly ash to ensure that it does not pose exposure risks to workers or building occupants. Although our research only confirmed indirect impacts to salmon habitat, cement manufacture is responsible for a huge portion of local and regional air pollution and greenhouse gas emission burdens. These burdens can be greatly reduced with cement substitutes.

Other major products to examine under this credit are structural and fabricated steel products. These input items consistently appear as high priorities in terms of upstream environmental burdens for average U.S. construction of all three building types examined in this report, and are responsible for a large portion of local and regional air pollution and greenhouse gas emission burdens. In general, steel manufactured in electric arc furnaces (EAFs), such as with Birmingham Steel, are scrap-based manufacturers using primarily post-consumer feedstock such as cars as the feedstock. As indicated above, although there is a presumption that using recycled content feedstocks benefits the quantitative and qualitative burdens of emissions, further control enhancements are in order as even the EAFs are responsible for significant environmental releases.

As in *Resource Reuse*, above, an LCA approach to assessing environmental burdens reveals that many industrial processes produce usable by-products that are not technically post-industrial or post-consumer recyclables. They are used as processing agents or are physically different than the material or product being manufactured. Fly ash and slag are examples. Under the topic "recycled content materials and products" therefore, the BaselineGreen™ analysis supports the inclusion of by-product materials.

Cement

RECOMMENDED ACTION:

- Evaluate converting the Lafarge plant to a dry process
- Evaluate converting both plants to natural gas, a cleaner burning fuel resulting in decreased emissions, some of which are considered harmful to salmon
- Prohibit burning tire-derived and other chlorinated fuels in cement kilns.
- Accelerate use of fly ash as a replacement for portland cement in all concrete applications.

Fly ash is a byproduct of coal fired power plants and as such is characterized as a post-industrial recycled material. All fly ash has pozzolanic properties, while Class C fly ash has both pozzolanic and cementitious properties. Substituting fly ash for portland cement in concrete mixes yields several benefits. We recommend the minimum percentage replacement of portland cement with Class F fly ash (available in the Seattle market) based on input provided by the Seattle firm Mithun Architects + Designers + Planners as below:

- Post-tensioned concrete – 25%
- Raft slabs, slabs on grade and architectural concrete – 40%
- All other concrete – 50%

A high volume fly ash concrete mix will

not only contribute toward achieving the LEED™ credit for recycled content, but will also diminish the embodied energy of the concrete and reduce its global warming potential.

Sand and Gravel

RECOMMENDED ACTION:

- Substitute industrial byproducts from regional industries for virgin gravel.

Alternatives to gravel, such as industrial byproducts from regional industries (e.g., aluminum smelters, coal-fired power plant), and crushed and graded post-consumer glass, should be considered to alleviate demand on local virgin resources. Additionally, according to Washington Department of Natural Resources' scientists, crushed quarry rock is environmentally advantageous to gravel since more rock is produced from quarries for the surface disturbance and quarries can be located away from flood plains and aquifers. The reduced disruption occurs because most quarries contain 100 percent usable rock, vs. gravel deposits with high porosity (less material per volume) and fines that do not have economic value.[112]

Washington Aggregate & Concrete Association's Bruce Chatkin acknowledges the use of recycled aggregates in concrete design mixes, and of crushed glass used for utility trenches, but indicated that the costs associated with processing and grading recycled aggregates makes them prohibitive in many applications.[113] Seattle and other jurisdictions in the tri-county region should investigate strategies to lower costs to maximize the offset to virgin mineral stocks.

Credit 5: Local/Regional Materials

RECOMMENDED ACTION:

- Specify materials manufactured and sourced within 500 miles of the construction site.
- Compare LEED and BaselineGreen methodologies before specifying a material based on its location of extraction and manufacture.

Since this LEED™ credit calls for materials to be manufactured and sourced within 500 miles of the construction site, its scope is the entire State of Washington, and into Oregon and Canada.

LEED™ and BaselineGreen™ differ in their approaches to and recommendations for this topic. LEED™ recommends using local and regional products "across the board" as a means of reducing upstream environmental impact associated with the transport of goods and materials. However, an LCA approach reveals that there may exist much more harmful upstream burdens during the *extraction and manufacturing* stages of a material or product than during the *transport* stage. One should not assume outright that local and regional manufacturers have zero environmental burdens associated with their facility. In fact, the BaselineGreen™ analysis of average construction in the U.S. has informed us to initially assume otherwise. Thus, using local and regional materials is recommended only if an LCA approach is incorporated into the specification process.

Although the three BaselineGreen™ analyses indicated that, for average construction in the entire U.S., many building-related materials and products are associated with upstream toxic releases, air pollution, and greenhouse gas emissions, a review of the data suggests that local and regional industries in Seattle and the State of Washington are "cleaner and greener" than the U.S. average. In 1999, there were relatively small documented toxic releases to water, no toxic releases to land from local and statewide building-related industries, and toxic releases to air attributed to building-related industries were less than 5% of the statewide total. Therefore, specifying materials and products from local and/or regional manufacturers will not necessarily result in an increase"in associated upstream environmental burdens at the local and regional scale. With the exception of cement and fabricated steel products, the same can be said for upstream air pollutant and greenhouse gas emissions.

However, the above statement is made with caution. Many local and regional building related industries did report toxic releases to water, land, and air in previous years. Constant monitoring of upstream manufacturing impacts must be a part of any "buy local" program. The BaselineGreen™ analyses indicate that careful attention should be paid when specifying certain "high priority" building materials and products that consistently appear in average U.S. construction, though local and regional manufacturers were found to be "cleaner and greener." (See sidebar)

Cement and steel have been discussed above under *Materials & Resources* Credit 4. Lumber is discussed below under *Materials & Resources* Credit 7. Although paint products are addressed in LEED™ 2.0 under *Indoor Environmental Quality*, that topic does not address the concerns raised by BaselineGreen™. The upstream impacts of paint manufacture are better addressed as a *Materials & Resources* topic. The recommendation regarding paints is to comply with standards for chemical content set by Green Seal third party certification guidelines.

Credit 6: Rapidly Renewable Material

RECOMMENDED ACTION:

- Specify straw-based products as wood substitutes.
- Step up efforts to establish straw-based manufacturing capacity in Washington State.

Straw qualifies as a rapidly renewable material as its cycle from planting to harvesting falls within 10 years. As described above, Washington State is one of the nation's largest wheat producers and, as such, has the potential to manufacture a variety of straw-based products to replace products manufactured from wood, such as particleboard and medium density fiberboard. No such manufacturing capacity currently exists in Washington State. We recommend specifying straw-based products as wood substitutes, and encourage current efforts to establish straw-based manufacturing capacity in Washington State.

Credit 7: Certified Wood

RECOMMENDED ACTION:

- All new wood-based products used in construction projects in the tri-county region should be from FSC certified sources when they are cost-competitive and equal or superior in performance than non-certified wood products.

As discussed above, rough and finish wood products consistently appear as "high priority" inputs in average U.S. construction. However, with the exception of criteria air pollutant emissions, local and regional manufacturers were found to be "cleaner and greener" than the U.S. average. Although only indirectly affecting salmon habitat, the processing of finished wood products such as millwork and plywood is responsible for a huge portion of local and regional air pollution and greenhouse gas emission burdens. Specifying products certified by an independent third party program is one step that can be taken to begin to minimize the environmental impact of wood product

Table 14: High Priority Inputs in Average U.S. Construction

- Rough lumber products and processed lumber products such as plywood, waferboard, millwork, and wood cabinets (SIC codes 2421, 2426, 2431, 2436, 2491, 2493).
- Cement (SIC code 3241).
- Structural steel and fabricated steel products (SIC codes 3441, 3449).
- Paints (SIC code 2851)

manufacturing in the region. Based on the discussion with Mr. Hrubes of Scientific Certification Systems, the authors recommend that all new wood-based products used in construction projects in the tri-county region be from FSC certified sources when they are cost-competitive and equal or superior in performance than non-certified wood products.

The Indoor Environmental Quality section of LEED™ has the least potential impact to salmon, even though it has a direct impact to human health, particularly from an indoor air quality point of view. It is interesting to note the similarities between the substances tracked by the U.S. EPA and included in BaselineGreen™ and those associated with poor indoor air quality. Both CO2 (a greenhouse gas) and VOCs (a criteria air pollutant) fall into both categories. LEED™ allows one credit for CO2 monitoring, and places limits on VOCs from adhesives, sealants, paints, coatings, carpet, and wood binders.

Impacts to Salmon

The same toxic chemicals used in the manufacture of paint, engineered wood products, carpet, adhesives, and sealants that impair indoor air quality can result in upstream releases during manufacturing, and downstream releases associated with disposal and recycling. This is especially problematic when the chemicals are persistent bioaccumulative toxins, as these can affect salmon even if their release is a far distance from the habitat.

Paint

Green Seal provides a basis to evaluate paints based on VOC emissions and chemical ingredients, while ensuring that the paints fulfill high-level performance requirements. Two paint manufacturers in the tri-county region reported toxic releases indicating the use of chemicals prohibited by Green Seal. However, a closer examination of these manufacturers reveal that some of their respective products comply with Green Seal requirements. A third paint manufacturer located in Seattle, Best Paints, manufactures non-toxic paints with zero VOCs. However, a company representative did not disclose the chemical formulations; there were no reported toxic releases for Best Paints in the 1999 US EPA TRI reports.

While it is beyond the scope of this report to develop a toxicological analysis of these chemicals and salmon, our general point is that they may be contributing factors to salmon decline. In this regard, we recommend that a survey of best green chemical practices for paint manufacturers be undertaken to transition towards elimination of the targeted chemicals. Specifying locally manufactured paints that are Green Seal compliant would support the local economy and contribute to a healthier ecosystem.

Table 15: Paint manufacturers in the Seattle region and the areas of concern.

Company	Type of Product	VOC Level	Chemical Ingredients based on 1999 TRI Releases to Air
Farwest Paint Mfrg. Co. 4522 S. 133rd St. Riverton Heights, WA 98168	Household & industrial paints	Varying levels; some latex products are GreenSeal compliant; alkyd paints have VOC levels in excess of Green Seal allowable levels	Ethylene Glycol **3. Methyl Ethyl Ketone** N-Butyl Alcohol **Toluene** Xylene (mixed isomers) Latex products do not appear to be manufactured with the prohibited ingredients; some of the alkyd paints are manufactured with Green Seal prohibited ingredients
Parker Paint Mfg. Co.	Household & industrial paints	Varying levels; Klean air interioreggshell, satin & semi-gloss, Prokote interior eggshell latex, Great Northwest interior flat and eggshell latex are GreenSeal compliant	Ethylene Glycol N-Butyl Alcohol **4. Toluene** Xylene

Note: Chemical ingredients listed in **BOLD** print are on the list of Green Seal prohibited ingredients.

ID Innovation and Design Process

SS WE EA MR IEQ ID

LEED 2.0™ provides for four innovation points to recognize design and construction practices that exceed established LEED™ levels and that introduce strategies not recognized in LEED™.

Materials & Resources

1. Chemically-Treated Wood: Because all toxic releases to water from building-related industries within the State of Washington are from lumber treatment facilities that use creosote, Copper Chromated Arsenic (CCA), and pentachlorophenol, look for opportunities to substitute treated wood with naturally-resistant FSC-certified wood or with recycled wood-plastic composite wood. Alternatively, specify wood treated with a less toxic chemical formulation, such as ACQ (Ammoniacal Copper Quaternary) or CBA (Copper Boron Azole). (A 2002 U.S. EPA ruling will ban the use of CCA treatment for most categories of wood use by the end of 2003.) The City of Seattle's Department of Parks and Recreation is taking appropriate action by only specifying non-arsenate pressure treated products, such as CBA and ACQ (as per Standard No. 06000.01, January 22, 2002.)

In addition, because the non-CCA treated wood processes use copper, which can be toxic to aquatic animals, ensure that all manufacturers cover the stored wood to eliminate stormwater contamination

2. Alternatives to PBTs: For products that release PBT chemicals at some phase of their life-cycle, such as with PVC, paint, roofing, portland cement, copper, substitute materials and products that do not release these chemicals. In the case of fluorescent light bulbs, specify only those that contain lowest available mercury, recognizing that the energy savings accrued from fluorescent bulbs lessens other chemical emissions associated with fossil fuel-based electrical generation. PBT-free substitute materials and products are competitively priced and readily available for most building-related applications.

Conclusion

This section of the report highlights the primary impacts to salmon for all LEED™ categories, along with corresponding recommendations for the LEED™ salmon-friendly overlay. Recommendations for future work and further study will follow. The concluding remarks provide food for thought for reframing the problem of salmon decline.

Summary of Findings and Recommendations

In addition to summarizing the BaselineGreen™ results, five building related impacts to salmon are highlighted, along with corresponding salmon-friendly building strategies:

- stormwater runoff and impervious cover
- salmon-friendly hydro, greenhouse gas emissions and ozone depletion
- sand and gravel mining
- forest and agrifiber products
- toxic chemicals

BaselineGreen™

This life cycle-based analysis of building-related upstream impacts to salmon has shown that in the tri-county region and in the remainder of the State of Washington building related toxic releases to land and water were relatively small, while toxic releases to air were less than 5% of the statewide total. Except for cement, building-related criteria air pollutant releases were relatively small. Carbon dioxide (CO_2) emissions associated with the manufacture of cement and fabricated steel products account for a substantial portion of greenhouse gas emissions in the tri-county region and possibly in the remainder of the state. Thus the BaselineGreen™ analysis revealed relatively minor direct links – releases to water - between upstream environmental burdens associated with the manufacture of building materials and products and environmental factors detrimental to salmon habitat. Toxic releases to air, criteria air pollutants, and greenhouse gases associated with the manufacture of building materials are more substantial, but are also more indirect in their impacts to salmon. These somewhat surprising findings resulted in a more in-depth inquiry into other potential building-related impacts to salmon. The following five sections summarize the results of this research.

Stormwater Runoff and Impervious Cover

The authors acknowledge the substantial stormwater research efforts undertaken by the City of Seattle, other regional governmental and research entities, as well as by the State of Washington, and therefore direct specific inquiries to those bodies for analysis and recommendations as it is beyond the scope of this study.

Salmon-Friendly Hydro, Greenhouse Gas Emissions, & Ozone Depletion

Over 90% of Seattle's electricity is generated by hydropower facilities. As conventionally designed and operated, these are treacherous to salmon: dams can completely block the upstream migration of fish, even if equipped with fish ladders; reservoirs created by dams do not have the current needed to guide juvenile salmon to the ocean; dams modulate flow such that they eliminate the spring freshets that hasten salmon to the sea, and at other times release so much water that it sweeps fish out of the river before they are ready, and washes away gravel and sediment; pumps and turbines in dams often suck up fish and kill them. The City of Seattle should be commended for its longstanding commitment to salmon-friendly hydropower, as evidenced in the successful implementation of the Skagit River Hydroelectric Project, and adherence to practices consistent with the Low Impact Hydro Institute.

Even with its heavy reliance on hydropower, greenhouse gas emissions in the form of CO2 from building material related industries in the Seattle area are substantial. Greenhouse gases impact salmon through global warming which may diminish food supply in their ocean habitat, as well as adversely affect incubation and the timing and amount of flow volume in streams. The largest producers of CO2 are the two cement kilns on the Duwamish Waterway which generate this greenhouse gas in the production process. Fly ash, a by-product from coal fired power plants, may be substituted for portland cement in concrete mixes. The authors recommend that the City of Seattle pursue the use of high volume fly ash mix concrete to reduce the net impact of concrete on salmon when it is cost-competitive and equal or superior in performance to conventional concrete design mixes.Increased exposure to ultraviolet (UV) radiation, as happens as a consequence of stratospheric ozone layer depletion, can threaten salmon vitality. Because their eggs or larvae lie in shallow waters during early spring, they are vulnerable to heightened UV levels. A review of tri-county manufacturers revealed that two reported use of CFCs in the last available TRI documents, although these chemicals were banned in 1996. Alternatives to ozone depleting compounds for manufacturing processes and as refrigerants and fire suppression chemicals should be accelerated beyond the phase-out dates stipulated by the Montreal Protocol, and, at a minimum, compliance with the phase-out schedule should be verified among all tri-county manufacturers.

Sand and Gravel Mining

Sand and gravel are the most common aggregates in concrete. Mining in general has degraded America's surface waters more than any other activity, and sand and gravel mining are particularly harmful to salmon. Wet pit gravel extraction directly and adversely affects spawning beds, causes sedimentation, changes stream morphology, alters channel hydraulics, and causes pollution in the form of hydrocarbons, heavy metals, and herbicides. Since Washington State has the fifth largest supply of aggregates in the United States, and sand and gravel represent the most valuable production commodity mined in the state, gravel mining operations are ubiquitous, representing over 9000 acres in the tri-county region. The authors recommend alternatives to gravel such as industrial by-products (e.g., aluminum smelters, coal-fired power plant), crushed and graded post-consumer glass, and crushed quarry rock, strict monitoring of all current sand and gravel extraction processes, and adoption of NMFS gravel policy for consideration of new and renewed permits. Policies for grandfathering of permitted facilities should be carefully reviewed to ensure that practices that could contribute to salmon decline are discontinued.

Forest and Agrifiber Products

Since forested lands are major producers of wood and salmon, forest management practices must take both into account. Timber management practices can cause profound changes in channel morphology, light, temperature and flow regimes. They can also change the abundance of large woody debris which provides critical salmon microhabitat in streams.

Logging roads can contribute to salmon decline through sedimentation delivered to streams through mass wasting and erosion. What's more, fertilizers and pesticides commonly used in forestry can be toxic to salmon directly if they enter surface waters, and indirectly by affecting the food available to salmon. Based on discussions with one of the certifiers for the Forest Stewardship Council (FSC) identifying the accrued benefits associated with FSC certified products, the authors recommend specifying FSC-certified wood products and materials when they are cost-competitive and provide equal or superior performance than non-FSC certified wood products and materials. In addition to choosing products that ensure greater protection to salmon than non-FSC certified sources, this action will help to bolster market demand, and potentially catalyze an increase in FSC-certified forests, recognizing that at present less than 2% of Washington State's forested lands are FSC-certified. Furthermore, to reduce the burden on forests, the authors also recommend increased use of agrifiber products, such as wheat straw board, and support the establishment of wheat straw-based manufacturing businesses in the State of Washington, such as has been begun by the Washington Department of Community, Trade and Economic Development

Toxic Chemicals

Toxic chemicals, particularly persistent bioaccumulative toxins (PBTs), are a serious threat to salmon, since they increase the incidence of chemical effects, such as modification of DNA, and alter immune functions. In 2000 the U.S. EPA issued a general fish consumption advisory for the Puget Sound due to contamination from several pollutants, including PBTs. Both the State of Washington and City of Seattle acknowledge the environmental health toll associated with continued release of PBTs and are launching initiatives to begin eliminating their procurement. Indeed, in a 1 July 2002 Resolution, the Seattle City Council passed a resolution, introduced by City Councilwoman Heidi Wills, to reduce the purchase and use of persistent bioaccumulative toxics, instructing the City to forego the purchase of products that contain persistent chemicals or that result in the release of persistent pollution during their manufacture. The PBTs cadmium, dioxin, lead, and mercury are all found in building materials.   Cadmium is used as a stabilizer in polyvinyl chloride (PVC) and paints. Dioxins are emitted from cement kilns and as byproducts of vinyl chloride monomer processing and PVC combustion. Lead is also used as a stabilizer in PVC and to make roof flashing. Mercury is used in fluorescent light tubes, lamps, paint, and electrical switches. This resolution echoes our recommendation that the City of Seattle phase-out the use of PVC building materials, lead flashing and other lead roofing products as cost-competitive products of equal or better performance become available, specify paints that meet the Green Seal chemical requirements, and prohibit cement kilns from burning fuels that releases PBTs, and work with state and regional agencies to ensure the proper disposition of mercury containing light bulbs.

In addition, the authors note that the only reported toxic releases to water in the tri-county region originate from wood treatment facilities that use CCA, creosote, and pentachlorophenol chemicals. The U.S. EPA has banned the use of CCA for most wood applications by December 2003. However, despite the European Union's ban of creosote (scheduled for complete phase out by June 2003) due to heightened concerns of cancer risks, and, as of this writing, 26 countries that have banned pentachlorophenol*, both

* *All uses prohibited by final regulatory action due to health or environmental hazards:*
Austria, Benin, Columbia, Costa Rica, Denmark, Dominican Republic, Egypt, Germany, Guatemala, Hong Kong, India, Indonesia, Italy, Jamaica, Korea, Liechtenstein, Luxembourg, Malaysia, Moldova, Netherlands, Nicaragua, Panama, Paraguay, Sweden, Taiwan,Yemen

chemicals continue to have permitted uses in the U.S. Because of the broad risks to public and environmental health, and particularly because of risks posed to salmon, alternatives to CCA, creosote and pentachlorophenol wood treatment chemicals should be specified as they are cost-competitive and equal or superior in performance in the tri-county region, with an effort to accelerate the EPA-sanctioned CCA phase-out prior to the December 2003 deadline.

Further Study

The authors suggest refinement and expansion of the proposed salmon-friendly building practices by connecting this effort on the part of the City of Seattle with two other Seattle-based organizations; Sustainable Seattle and the University of Washington.

Coordination with Sustainability Indicators

It is no surprise that many of the building related impacts to salmon previously highlighted in this study are already tracked as part of Sustainable Seattle's Indicators of Sustainable Community program.

It may be helpful to compare building-related historical data, such as number of permits issued, or housing starts, with these indicators to see if a correlation may be found. Of course, the most important correlation would pertain directly to wild salmon runs. But all of the other indicators have links to both salmon and buildings. Such correlations could then be used to prioritize and guide salmon-friendly building practice implementation. At a minimum, these indicators can be used to measure the effects of salmon-friendly building practice implementation.

Collaboration with Urban Ecology Simulation

We suggest a collaboration between the City of Seattle and the urban ecology modeling work underway by Dr. Marina Alberti at the University of Washington's Department of Urban Design and Planning to assess the impacts of building scenarios on salmon and stream quality. The preliminary findings of this research suggest that land cover change associated with urban development has adverse affects on stream quality. This work could overcome some of the shortfalls of BaselineGreen™ which is not structured to inventory and map regional erosion and sedimentation related to upstream building activities, such as logging and mining, nor to handle other supply chain activities that may have other environmental impacts, such as loss of vegetation, other changes in land cover, and fertilizer, pesticide, and herbicide use.

impacts, such as loss of vegetation, other changes in land cover, and fertilizer, pesticide, and herbicide use.

Concluding Remarks

This study has provided insights relative to enhancing the environmental health performance of buildings, particularly in ways advantageous to salmon, and applied them to the U.S. Green Building Council's LEED™ 2.0 rating system. Although this complies with the original purpose and scope of this study, adhering to these "salmon-friendly" building practices is not enough to reverse salmon decline in the Seattle area. The authors believe this to be true for several reasons:

> **First,** other aspects of urbanization besides buildings, such as roads and other types of infrastructure, have substantial negative impact to salmon;
>
> **Second,** regional industries not associated with the production of building materials, such as pulp and paper, have huge negative impacts to salmon.
>
> **Third,** many of the measures in the salmon-friendly LEED™ overlay have to do with either mitigation or conservation, activities which will not necessarily address the root of the problem, but will lessen the impact of a problem which must necessarily be addressed as systemic.

The third reason, inspired in part by the work of William McDonough and Michael Braungart, is a bit unwieldy and has as much to do with how we *frame* this salmon problem as to how we *solve* it.[114] Many of the recommended strategies have to do with eco-efficiency, using fewer resources and releasing less pollution. Yet addressing systemic problems requires systems thinking, and eco-efficiency does nothing to change the system. A good start on this tack would be to ask: how do we make the life cycle of a building truly a cycle? The simple answer is through development of an industrial ecology. The ultimate question may be: how do we not only lessen the impacts to salmon, but regenerate salmon, or perhaps provide the opportunity for salmon populations to regenerate themselves? There is no simple answer to this question, since it implies, among other outcomes, buildings that produce more or cleaner water than they consume, and that produce more power than they consume. More pointedly, we could ask: as a barometer of ecosystem health, what are the salmon telling us about the relationship between our industrial, constructional, and business practices as well as our lifestyle choices and living in balance with the natural systems upon which all life depends? As Chief Seattle said in his famous speech of 1854: "Man did not weave the web of life, he is merely a strand in it."

Notes

[1] Sustainable Seattle, *Indicators of Sustainable Community 1998*, Seattle, Washington. April 1998.
[2] Brad Knickerbocker, "Seattlites look to save energy – and fish, too". *The Christian Science Monitor*, 2/13/01, pg. 3.
[3] Washington State Department of Ecology, Water Quality Division, *Stormwater Management Manual for Western Washington*, Publication Numbers 99-11 to 99-15, August 2001.
[4] National Research Council, *Upstream: Salmon and Society in the Pacific Northwestˆ, National Academy Press,* Washington, DC, 1996.
[5] Frank Vinluan, "State's Population grows 21 percent in '90s", *Seattle Union Record,* 12/29/2000.
[6] Federation for American Immigration Reform (FAIR), Seattle-Tacoma-Bremerton Consolidated Metropolitan Area: Summary Metro Area Data, March 2002, www.fairus.org/html/msas/042wastb.htm
[7] Stuart Cowan, *Salmon-Friendly Streets Case Statement*, 9/11/2000.
[8] Cumulative Risk Initiative, Northwest Fisheries Science Center, "A Standardized Quantitative Analysis of Risks Faced by Salmonids in the Columbia River Basin", NMFS-NOAA, 17 July 2000, Draft Document
[9] National Research Council, *Upstream: Salmon and Society in the Pacific Northwestˆ, National Academy Press,* Washington, DC, 1996, p. 30.
[10] *Ibid*., p. 29
[11] Brian Moss, "Biodiversity in fresh waters – an issue of species preservation or system functioning?". *Environmental Conservation 27*, Foundation for Environmental Conservation, pp. 1-4.
[12] United Nations Environment Programme, "Rio Declaration on Environment & Development", Article 15, June 1992.
[13] Wingspread Statement on the Precautionary Principle, Racine, WI, 25 January 1998.
[14] "Nonfishing Activities Affecting Salmon Habitat", www.psmfh.org/efh/Jan99-sec3-23Antml
[15] LEED™ is an acronym for Leadership in Energy and Environmental Design, a green building rating system generated by the U.S. Green Building Council, www.usgbc.org
[16] These deficiencies are to be addressed in future iterations of the BaselineGreen™ tool.
[17] Criteria Air Pollutants include nitrogen oxides, sulfur dioxide, particulate matter, volatile organic compounds (VOCs) and carbon monoxide.
[18] http://nadp.sws.uiuc.edu/isopleths/
[19] www.usgbc.org
[20] Nawa and Fressell, 1993
[21] Chapman, 1988.
[22] Lotspeich and Everest (1983)
[23] Wildlife and Pollution," *Essays in Wildlife Conservation*, www.meer.org/chap8.htm
[24] Alex Wilson, "Cleaning Up Stormwater", *Environmental Building News*, Vol. 11, No. 2, February 2002, pg. 12.
[25] "Factors Affecting Chinook Populations -- Background Report," prepared under contract to the City of Seattle by Parametrix Inc., Natural Resources Consultants, Inc., Cedar River Associates, June 2000, pp. 78-79.
[26] "Seattle's Urban Blueprint Document -- Seattle's Aquatic Environments: Duwamish

Estuary," prepared by City of Seattle's Salmon Team, Seattle Public Utilities, June 2000.
[27] Review of the 29 April 1999 "Forests and Fish Report" and of Associated "Draft Emergency Forest Practice Rules", Review prepared at the request of the American Fisheries Society and the Society for Ecological Restoration, 31 January 2000.
[28] Alex Wilson, "Cleaning Up Stormwater" Environmental Building News, February 2002, Vol. 11 No. 2, p. 13.
[29] KRIS Noyo System, www.krisweb.com/index.htm, 10/9/01
[30] "Can Science Rescue Salmon?", *Science*, 4 August 2000.
[31] C. May et.al., 1996. "Assessment of Cumulative Effects of Urbanization of Small Streams in the Puget Sound Lowland Ecoregion." Presented at the Urban Streams Conference, Arcata, CA, November 15-17, 1996.
[32] Richard R. Horner et al., "Impervious Cover, Aquatic Community Health, and Stormwater BMPs: Is there a relationship?"
[33] www.crcwater.org/fish
[34] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-23Antml
[35] "Water runoff rates and floods, untitled document, yahoo, pg. 14.
[36] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-23Antml
[37] Personal communication with Bruce Chatkin, March 18, 2002
[38] Salmon-Safe, Inc. *Salmon-Safe® Farm Management Certification Program*. Field Assessor's Guidelines 4.0. June 2002.
[39] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-23Antml
[40] www.greenroofs.com/ecological.htm
[41] www.roofmeadow.com/benefits.html
[42] www.ci.seattle.wa.us/util/watershed/cedar/hcp/overview.htm
[43] *Ibid*.
[44] www.ci.seattle.wa.us/util/tolt2/overview.htm
[45] 1997 Biennial Energy Report, Section 2: The Electric Industry in Washington – Turmoil and Transition
[46] *Ibid*.
[47] Brad Knickerbocker, "Seattlites look to save energy—and fish, too", *The Christian Science Monitor*, 2/13/01/ pg. 3.
[48] City of Seattle, Resolution 30144, April 3, 2000
[49] City of Seattle, Resolution 30359, July 23, 2001.
[50] Patrick Mazza, "The Environmental Decline of the Northwest: An Index", *Cascadia Planet*, Copyright 1995.
[51] Ecotrust.org
[52] Office of the Governor, Washington State, "The State of Salmon," 2000.
[53] *Skagit River Hydroelectric Project: Low-Impact Certification*. October 6, 1999.
[54] Peter Dobrovolny, Seattle Public Utilities, personal communication, December 2, 2002.
[55] Kathryn Brown, *Science*. Vol. 290, 27 October 2000, p. 686.
[56] Cumulative Risk Initiative, Northwest Fisheries Science Center, "A Standardized Quantitative Analysis of Risks Faced by Salmonids in the Columbia River Basin". NMFS-NOAA, 17 July 2000.
[57] Steve Moddemeyer, Seattle Public Utilities, personal communication, 7/31/02.
[58] Arctic Monitoring & Assessment Programme, *Arctic Pollution Issues: A State of the Arctic Environment Report*, 1997.
[59] Personal communication with Corinne Grande, Seattle City Light, 1/3/02.

[60] www.energy.cted.wa.gov/BIENREPO/SEC2.HTM#SEC2BOX
[61] William R. Meehan, editor, *Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats*. American Fisheries Society Special Publication 19, Bethesda, Maryland, 1991, www.fisheries.org
[62] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-23Antml
[63] *Ibid.*
[64] *Ibid.*
[65] David K. Norman, C Jeff Cederholm, William S. Lingley, Jr., "Flood Plains, Salmon Habitat, and Sand and Gravel Mining", *Washington Geology*, Vol. 26, No. 2/3, September 1998, pp. 3-20.
[66] Center for Streamside Studies, University of Washington, Colleges of Forest Resources and Ocean and Fishery Sciences, "Environmental Impacts of Hardrock Mining in Eastern Washington", undated.
[67] *Ibid.*
[68] Personal communication with Bruce Chatkin, Executive Director, Washington Aggregate & Concrete Association, 3/18/02.
[69] Washington Aggregate and Concrete Association, www.washingtonconcrete.org
[70] Alex Wilson, "Cement and Concrete", Environmental Building News, March/April 1993 (vol.2 no. 2) pp. 1- 7.
[71] V. M. Malhotra, "Making Concrete "Greener" With Fly Ash", *Concrete International*, May 1999, pp. 61-66.
[72] Puget Sound Business Journal, *Project will cut water use at thirsty Seattle cement plant*, November 2, 2001.
[73] Data derived from personal correspondences: Lafarge: Russ Simonson, Environmental Engineering, Lafarge, Seattle, WA, 4/16/02; Ash Grove: Fran Streitman, Vice President, Environmental Affairs, Ash Grove Cement company, Overland Park, Kansas, 4/15/02.
[74] Washington Concrete Association, "Washington Aggregates", www.washingtonconcrete.org., January 6, 2000.
[75] *Ibid.*
[76] David K. Norman, C Jeff Cederholm, William S. Lingley, Jr., "Flood Plains, Salmon Habitat, and Sand and Gravel Mining", *Washington Geology*, Vol. 26, No. 2/3, September 1998, pp. 3-20.
[77] *Ibid.*, pp. 3-20.
[78] U.S. Department of Commerce, NOAA, NMFS, Memorandum from Rolland A. Schmitten, undated.
[79] Spence et. al. 1996
[80] National Marine Fisheries Services, Northwest Region, "Endangered Species Act Sectin 7 Consultation, Biological Opinion, Dooher Bar Gravel Extraction and Bank Protection on the Kilchis River, Corps No. 1999-01-01126, Tillammook County, Oregon", 14 September 2000.
[81] www.psmfc.org/efh/Jan99-sec3-23C.html, pg. 3.
[82] David Malin Roodman and Nicholas Lenssen, *A Building Revolution*, Worldwatch Institute Paper 124.
[83] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-23Antml
[84] Dave Iverson, Hillary Lauder, Randy Scott, Christine Winkelman, "The Growth Management Act and Salmon", http://192.211.16.13/curricular/salmon/growthmanage.htm
[85] "Non-fishing activities Affecting Salmon Habitat," www.psmfh.org/efh/Jan99-sec3-

Notes

23Antml

[86] *Ibid.*

[87] http://www.nmfs.noaa.gov/prot_res/PR3/Fish/salmon_impacts.html

[88] Forest Stewardship Council, "Pacific Coast Regional Standards", Draft 3.20, 6 April 2000.

[89] www.primeboard.com/efb.html

[90] Agriculture in Washington State, Farm Service Agency, Washington State Online, www.fsa.usda.gov/wa/agin.htm

[91] Personal communication with Ray Isaacson, Washington Department of Community, Trade & Economic Development, 1/11/02.

[92] Joel S. Levine, Wesley R. Cooper III, Donald R. Calhoon, Jr., and Edward L Winstead, "The Global Impact of Biomass Burning", *Environmental Science and Technology* (March 1995).

[93] "Nonfishing Activities Affecting Salmon Habitat", www.psmfh.org/efh/Jan99-sec3-23Antml

[94] Alison Vollbracht, "Salmon & Toxic Chemicals: A Review of the Scientific Literature", People for the Puget Sound, July 1998.

[95] Ibid.

[96] U.S. Environmental Protection, Office of Pollution Prevention and Toxics, "EPA's Persistent, Bioaccumulative and Toxic Chemical Program," http://www.epa.gov/pbt/home.htm, March 2001.

[97] Office of Water, U.S. Environmental Protection Agency, "EPA Fact Sheet - Update: National Listing of Fish and Wildlife Advisories", EPA-823-F-01-010, April 2001.

[98] *Ibid.*

[99] Barbara Harper, Yakima Indian Nation, Stuart Harris, Confederated Tribes of the Umatilla Indian Reservation, "Tribal Technical Issues in Risk Reduction Through Fish Advisories", 1999 American Fisheries Society Forum on Contaminants in Fish Proceedings, pp. 17-24.

[100] *Ibid.*

[101] For additional information contact Seattle's Conservation Help Line at 206/684-3800.

[102] Alison Vollbracht, "Salmon & Toxic Chemicals: A Review of the Scientific Literature", People for the Puget Sound, July 1998.

[103] Laurie Valeriano, Washington Toxics Coalition, personal communication, 1/4/02

[104] Joe Thornton, Ph.D., "Environmental Impacts of Polyvinyl Chloride (PVC) Building Materials", November 2000.

[105] *Ibid.*

[106] GNET, 9/27/02, Global Environment & Technology Foundation, Annandale VA

[107] Danish EPA 2000, "Alternatives to Lead Flashing," Environmental Project No. 593, COWI Consulting Engineers and Planners A/S, Jakob Maag, 2000.

[108] Washington Toxics Coalition, *Alternatives*, Spring 2001, Vol. 20, No. 2.

[109] Based on data received from officials at Ash Grove and Lafarge Cement companies, 2002.

[110] Washington Toxics Coalition, *Alternatives*, Spring 2001, Vol. 20, No. 2.

[111] Environmental Defense Scorecard, www.scorecard.org/env-releases/facility.tcl?tri

[112] David K. Norman, C. Jeff Cederholm, William S. Lingley, Jr., "Flood Plains, Salmon Habitat, and Sand and Gravel Mining." *Washington Geology*, Vol. 26, No. 2/3, Sept. 1998, pp. 3-20.

[113] Personal communication with Bruce Chatkin, Executive Director, Washington Aggregate & Concrete Association, March 18, 2002.

[114] http://www.theatlantic.com/issues/98oct/indust2.htm

Appendix A

BaselineGreen™ Report

Table of Contents

A1.0 Objectives 79

A2.0 Background 81

A2.1 Environmental Factors Contributing to Salmon Habitat Loss 81

A2.2 Prioritizing Environmental Factors Contributing to Salmon Habitat Loss 84

A2.3 Upstream Environmental Impacts Relative to Full Building Life Cycle 85

A2.4 Ustream Environmental Impacts Relative to Annual Value of Construction of Different Building Types 86

A2.5 Upstream Environmental Impacts: Various Building Scenarios 87

A3.0 Methodology 91

A4.0 Findings 95

A4.1 BaselineGreen™ Analysis 1: A Typical Mixed-Use/Commercial Project (the SJC Project) 95

A4.2 BaselineGreen™ Analysis 2: Model of Environmental Burdens Associated with Average National New Construction of Three Building Types 98

A4.3 BaselineGreen™ Analysis 3: Model of Environmental Burdens Associated with Regionally Based New Construction of Three Building Types 104

A4.3.1 Upstream Environmental Burdens in King, Pierce, and Snohomish Counties 104

A4.3.2 Upstream Environmental Burdens in the Rest of the State of Washington 107

A4.4 Summary of Three BaselineGreen™ Analyses 109

A4.5 Toxic Release Inventory, Air Pollution, and Greenhouse Gas Emissions Data for Industrial Facilities 116

A4.5.1 Toxic Releases to Water 116

A4.5.2 Toxic Releases to Land/Underground 118

A4.5.3 Toxic Releases to Air 119

A4.5.4 Air Pollution 122

A4.5.5 Greenhouse Gases 123

124 A4.6 Discrepancies Between BaselineGreen™ Finding and Review of Toxic Release Inventory Data for Industrial Facilities

127 A5.0 Conclusions and Recommendations

A1.0 Objectives

A BaselineGreen™ analysis of new construction in the Seattle metropolitan three-county region of three building types - office, commercial, and residential - was performed in order to:

> a) examine the upstream (i.e., supply chain) external environmental burdens associated with the manufacture of all identifiable material and product inputs to construction of the three building types,
>
> b) investigate how these burdens may adversely affect salmon habitats, and
>
> c) propose design and construction guidelines for avoiding or minimizing upstream environmental burdens that directly or indirectly affect salmon habitat.

The main objective of the analysis is to aid the City of Seattle in identifying "salmon friendly" building methods and practices in the City's effort to preserve, restore, and protect the many salmon habitats along its urban shorelines and in its many rivers, lakes, streams, and man-made waterways. The design and construction of "salmon friendly" buildings is one of a variety of strategies being pursued by the City of Seattle to achieve the goal of restoring and protecting sustainable, healthy salmon habitats throughout the Puget Sound region.

A2.0 Background

A2.1 Environmental Factors Contributing to Salmon Habitat Loss

Habitat loss and degradation has been identified as the major environmental cause of declining salmon populations in the Northwest. Environmental factors contributing to habitat loss and degradation may be roughly divided between historical modifications to shorelines, rivers, and streams and continuing or on-going activities or conditions affecting ecosystems that support salmon.

Historical modifications to Seattle's watersheds during the past century include physical alterations to the environment for the purposes of natural resource extraction, navigation, transportation accessibility, flood control, water supply, and land creation. The consequent landscape-scale land use and land cover changes profoundly affected salmon habitats. The negative impacts include loss of estuaries, loss of access to habitats, forced diversions in migration routes, urbanization of shorelines and stream and river banks, and major alterations to the hydrology of rivers and streams that support fish. These modifications, although related to building design and construction on a large scale, are better addressed as urban or regional planning issues. It is important to acknowledge these factors as many continue to adversely affect salmon populations, but they lie outside the scope of this BaselineGreen™ analysis.

The BaselineGreen™ analysis addresses some of the continuing biochemical environmental stressors to salmon habitat associated with building design and construction. Human-induced environmental (i.e., non-predator/competitor and non-natural event) factors contributing to habitat loss and degradation in all types of habitat – freshwater, estuary, and saline water – can be sorted into two broad categories: water quality and water quantity/rate of flow. The major environmental factors in each of these two categories are summarized in Table A2.1.1.

Table A2.1.1: Summary of Environmental Factors Contributing to Salmon Habitat Loss and Degradation

Water Quality	Water Quantity/Flow
Toxic releases and sediment contamination	Too much water (stormwater runoff)
Erosion, sedimentation, and turbidity	Too little water
Water temperature fluctuations	Barriers, channels, and diversions

Source: "Factors Affecting Chinook Populations, Background Report" prepared for the City of Seattle by Parametrix Inc., Natural Resources Consultants, Inc., and Cedar River Associates, June 2000.

Previous research by others has investigated how the environmental factors affecting salmon habitat may vary for each geographic area or watershed in the Seattle region. In Table A2.1.2 on the following page, for each of five identifiable geographic areas in Seattle, the factors that do and do not play a role in significantly contributing to salmon habitat loss are summarized.

Common to all five geographic areas in the City of Seattle is the fact that toxic releases, both spills from point sources and discharges from non-point sources, can occur with significant impact to salmon habitats. The impact of a toxic spill or discharge on salmon habitat would depend on the concentration of the substance, its properties and persistence, the rate and total volume of the discharge, the area of habitat affected by the spill, and the time of year the spill occurred. While toxic releases to water may have occurred in the past, they have been significantly reduced over the past two decades due to state and federal clean water regulations (see section 4 below).

Urban streams appear to have the most exposure and highest susceptibility to all environmental factors affecting salmon habitat. The quantity of water in Seattle's urban streams is greatly affected by a lack of stormwater retention in the drainage basins. Resulting environmental impacts include alternate flooding and dry periods, sedimentation, scouring, and low summer base flows. In addition, water quality in small streams is affected by stormwater runoff. Earlier studies have indicated the presence of hundreds of chemical compounds from streets, highways, and other developed urban areas. Several non-point sources were identified including automobiles, leaking septic fields, and household fertilizer use.

Large bodies of water such as Lake Washington and the Puget Sound shoreline apparently have the least susceptibility to many of the environmental factors listed above. The relatively large volume of water in these salmon environments makes them more resilient to short term environmental stresses than small rivers and urban streams. For example, stormwater runoff may temporarily impact a localized area of a lake or shoreline, but the (typically) short duration and dilution of the runoff will likely limit the negative effect on salmon habitat in proximity to the runoff event.

Outside the City of Seattle, and especially in the two surrounding watersheds (the Cedar/Sammamish and the Green/Duwamish), all of the environmental factors listed in Table A2.1.1 play a role in contributing to salmon habitat loss and degradation. Factors affecting water quality include the presence of contaminants and/or pollutants in some tributaries, sedimentation, and increasing water temperatures (apparently weather induced). Factors affecting water quantity/flow include high and low water level problems associated with uncontrolled stormwater runoff and a large number of flood control structures and diversions that are barriers to salmon migration.

Table A2.1.2: Likelihood of Environmental Factors Contributing to Salmon Habitat Loss and Degradation Occurring in Each of Five Seattle Geographic Areas

Geographic Area	Factors that Likely Do Have Significan Impact in the Area	Factors that Likely Do Not Have Significant Impact in the Area
Lake Washington	• Toxic releases (spills or large scale discharges such as from pesticides)	• Toxic discharges from stormwater runoff • Water temperature changes from stormwater runoff • Too much water - stormwater runoff • Barriers, channels, diversions
Lake Union System	• Toxic releases • Sediment contamination (historical) • Water temperature fluctuations (climatic causes) • Barriers, channels, and diversions (locks, ship canal, bulkheads)	• Toxic discharges from stormwater runoff • Water temperature changes from stormwater runoff • Too much water - stormwater runoff
Duwamish River and Elliot Bay	• Toxic releases • Sediment contamination (historical)	• Toxic discharges from stormwater runoff • Water temperature changes from stormwater runoff • Too much water - stormwater runoff • Barriers, channels, diversions
Puget Sound Shorelines	• Toxic releases • Barriers, channels, and diversions (piers, bulkheads)	• Toxic discharges from stormwater runoff • Water temperature changes from stormwater runoff • Too much water - stormwater runoff
Urban Streams	• Toxic releases • Toxic discharges from stormwater runoff • Erosion, sedimentation, and turbidity • Water temperature changes from stormwater runoff • Too much water - stormwater runoff • Too little water - lack of stormwater retention • Barriers, channels, diversions	

Source: "Factors Affecting Chinook Populations, Background Report" prepared for the City of Seattle by Parametrix Inc., Natural Resources Consultants, Inc., and Cedar River Associates, 06/2000.

The scope of the BaselineGreen™ analysis is much narrower than the diverse origins of the many environmental factors discussed above (see Tables A2.1.3 and A2.1.4 below). Its focus is on the upstream supply chain, or bill of material inputs to building design and construction. It examines three upstream environmental burdens associated with these inputs - toxic releases, air pollutants, and greenhouse gases – using available national and state data for industrial facilities (point sources) that annually report toxic releases to water, land, and air and criteria air pollutants. This data is used to portray the typical toxic release inventory and air pollution history of several different industry groups. (See Methodology section below.)

Toxic releases to water have a direct and significant impact on water quality. Toxic releases to land (or in underground storage) can seep into ground water sources and aquifers and eventually enter lakes, rivers, and streams. Toxic releases to air and criteria air pollutants can return to land and bodies of water through the process of atmospheric deposition. Greenhouse gas emissions can contribute to global warming and subsequently contribute to increases in water temperature and perhaps water level fluctuations.

Table 2.1.3: Building and Urban Development Associated Environmental Burdens Detrimental to Water Quality Sorted by Origin
(Shaded cells indicate scope of work of the BaselineGreen™ analysis.)

	Environmental Factor	Building and Development Related Issue	Industrial Facility/ IndustryGroup	Urban Scale	Watershed / Regional Scale	State Scale	National Scale	International Scale
Water Quality (Freshwater, Estuary, and Saline Habitats)	Toxic Release Contamination	Toxic releases to water	√	√	√			
		Toxic releases to land/underground	√	√	√			
		Toxic releases to air	√	√	√			
		Air pollutants	√	√	√			
	Water Temperature Changes	Greenhouse gases	√	√	√			
		Impervious cover		√	√			
		Land use and land cover changes		√	√	√	√	√
	Erosion, Sedimentation and Turbidity	Impervious cover		√	√			
		Land use and land cover changes		√	√	√	√	√
		Logging and mining			√	√	√	√

Table 2.1.4: Building and Urban Development Associated Environmental Burdens Detrimental to Water Quantity Sorted by Origin
(None of these building and development issues is included in the BaselineGreen™ analysis.)

	Environmental Factor	Building and Development Related Issue	Industrial Facility/ Industry Group	Urban Scale	Watershed / Regional Scale	State Scale	National Scale	International Scale
Water Quantity and Flow (Primarily Freshwater and Estuary Habitats)	Too Much Water	Impervious Cover		√	√			
		Dredging, Filling Channelization		√	√			
		Land Use/Land Cover Changes		√	√	√	√	√
		Logging And Mining			√	√	√	√
		Channels and dams	√	√	√			
	Too Little Water	Municipal, Industrial, Agricultural Use	√	√	√			
		Lack of retention	√	√	√			
	Barriers and Diversions	Land Use/Land Cover Changes		√	√	√	√	√
		Dams	√	√	√			

Erosion, sediment deposition, and turbidity can be a result of logging and quarrying activities. The BaselineGreen™ analysis does not attempt to examine these links. Additionally, as stated above, urban development modifications to shorelines, rivers and streams – impervious cover, barriers, channels and dams – are not within the scope of this work.

Table A2.1.3 on the previous page indicates the scale of *origin* of environmental factors affecting **water quality**. The shaded cells in Table A2.1.3 indicate the scope of work of the BaselineGreen™ analysis relative to all of the environmental factors described above. BaselineGreen™ focuses on environmental burdens that originate upstream from manufacturing inputs to buildings. These manufacturing inputs are usually industry groups that can be broken down into identifiable "point source" industrial facilities.

Table A2.1.4 on the previous page indicates the scale of origin of environmental factors affecting **water quantity**. BaselineGreen™ does not address any environmental factors affecting water quantity.

In each table a check indicates an environmental impact to salmon habitat and the scale at which the impact typically originates. Some are more local impacts such as point source toxic releases to water, some are more state and national in scale such as logging, and some are both such as air pollutants. Toxic releases, air pollutants, and greenhouse gases become urban, regional, and even statewide problems when automobile and truck modes of transportation of goods and services are included. Land use and land cover changes, as well as logging and mining activities, can become national and even international in scale when the watersheds in which the activities are located cross state and national political boundaries (e.g., Washington and British Columbia).

A2.2 Prioritizing Environmental Factors Contributing to Salmon Habitat Loss

Within the scope of the BaselineGreen™ analysis, the upstream building-related environmental burdens linked to the above factors were prioritized from most direct to least direct impact on salmon habitat as follows:

- Most direct: Toxic releases to water,
- Toxic releases to land/underground,
- Toxic releases to air,
- Criteria air pollutants,
- Least direct: Greenhouse gases.

As mentioned above, the direct link between toxic releases to water or land and water quality is self-evident. Toxic releases to air and criteria air pollutants are less direct factors since the process of atmospheric deposition must occur to accrue airborne toxics and pollutants on land or in bodies of water. Atmospheric deposition also disperses and dilutes toxics and pollutants over a widespread area. Most of the State of Washington is rated as having low to moderate susceptibility to the process and documented levels of many pollutant indicators have not increased over the past 20 to 30 years.

Although greenhouse gas emissions can lead to global warming, they are considered to be the least direct environmental factor since many steps and processes are involved in their connection to increased surface water temperatures. Moreover, many other factors contribute to climate changes that influence increasing air and water temperatures such as non-point source pollution (automobiles), urban heat islands, and vegetative cover.

Outside the scope of the BaselineGreen™ analysis, other urban and regional scale building and development activities are linked to the environmental factors contributing to salmon habitat loss and degradation. These include the following:

- Logging and quarrying activities,
- Transportation issues,
- Percent of impervious cover,
- Land use and land cover changes,
- Changes to and loss of wetlands,
- Dredging, filling, and channelization of rivers and streams,
- Diversions and dams,
- Municipal, industrial, and agricultural water use.

A2.3 Upstream Environmental Impacts Relative to Full Building Life Cycle

Upstream environmental burdens associated with building construction should be put in context relative to the environmental burdens that occur over a building's entire life cycle. In terms of prioritizing municipal policies or actions that may have the most significant effect in minimizing or eliminating these burdens, it would be helpful to know whether or not the upstream burdens are more, less or equal to burdens associated with other stages of a building's life cycle - the use phase (building occupancy) or post-use phase.

In the case of toxic releases, upstream environmental burdens associated with building materials and products likely represent a majority of the toxic releases associated with the full life cycle of a building (Figure A2.3.1 on the following page). This is due to the fact that many industries typically use several chemicals and substances classified as toxic in processing materials and products. Many of these are not included in the content of the final material or product but are used as processing agents. Although many of these chemicals and substances are recycled within the facility for reuse, the toxic release data indicates that large quantities are discharged as air emissions and similar amounts are typically transferred off-site to landfills or recycling operations.

In the case of air pollutants and greenhouse gases, the upstream life cycle stage represents a small portion of total burdens associated with full building life cycle. For example, in the case of the Seattle Justice Center (SJC) project, it was estimated that upstream burdens were equivalent to approximately 5-10 years of operation of a typical office/commercial mixed-use building. This is due to the fact that the energy consumption over the useful life of a typical office/commercial building generates a greater amount of air pollution and greenhouse gases emissions due to fossil fuel combustion in the generation of purchased electrical power. This is also due to the fact that, as the building is maintained and modified over time, environmental burdens associated with maintenance and remodeling activities also accumulate. In the case of air pollution and greenhouse gases therefore, purchasing electricity for the building from "salmon friendly" power sources may also be a significant factor to address as well as upstream toxic release burdens.

Thus it appears that upstream supply chain activities are the life cycle stage of a building when toxic releases are most significant. Air pollutants and greenhouse gases are relatively less significant upstream and relatively more significant during a building's use or occupancy stage.

A2.4 Upstream Environmental Impacts Relative to Annual Value of Construction of Different Building Types

Upstream environmental burdens associated with building construction should also be put in context relative to the volume or economic value of different building types constructed in the region. When prioritizing municipal policies or actions that may have the most significant effect in minimizing or eliminating these burdens, it would be helpful to know which building type or types has the greatest environmental impact – residential, office, or commercial.

One way of estimating the relative environmental burdens of each of the three building types is to review annual building permit data. This data includes the number of building permits issued, the building use definition (by code) for each permit, and the estimated construction cost of each project. Since the BaselineGreen™ methodology (see Section A3 below) links environmental burdens to the economic activity of an

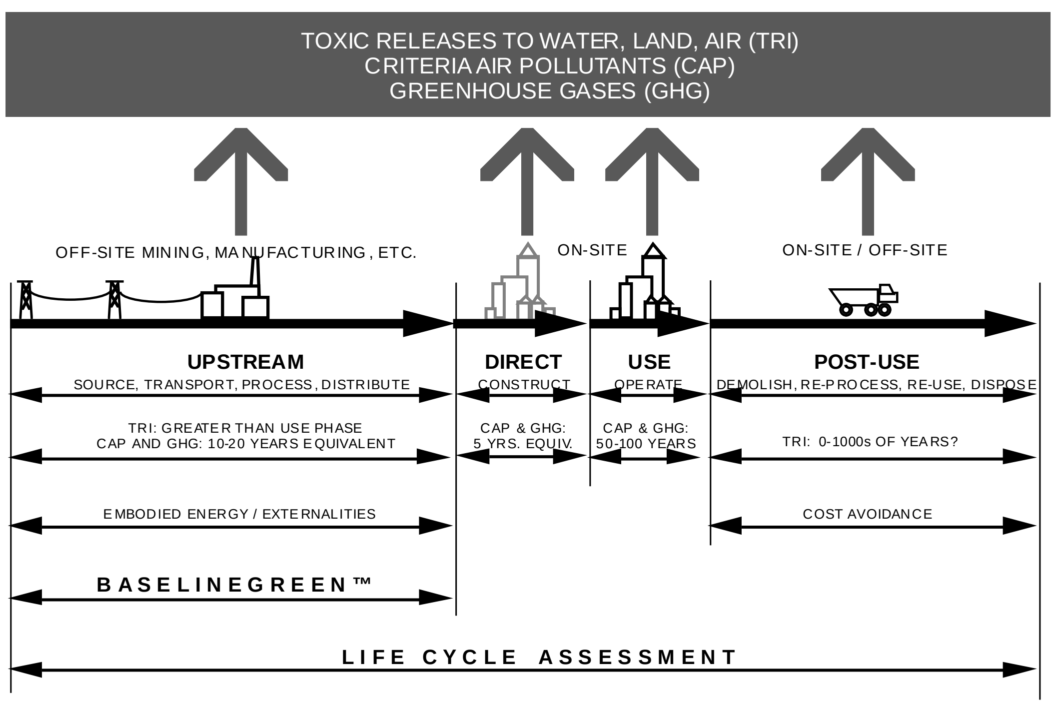


Figure A2.3.1: Relative Impact of Toxic Releases, Criteria Air Pollutants, and Greenhouse Gas Burdens Throughout an Entire Building Life Cycle

Toxic releases to water, land, and air, as well as air pollution and greenhouse gas emissions are associated with each stage of a building's life cycle. Upstream manufacturing of building materials and products typically accounts for a higher amount of toxic releases than other life cycle stages of a building. However, upstream manufacturing of building materials and products typically account for a much lesser amount of air pollution and greenhouse gas emissions than the use life cycle stages (occupancy) of a building. Typically, environmental burdens from energy consumption from fossil fuel generated sources and maintenance and repair activities outweigh upstream burdens. The post-use (downstream) stage of a building's life cycle may pose public health risks and environmental impacts if the materials and products used in the building contain hazardous substances (e.g., asbestos or lead). The BaselineGreen™ analysis examines the environmental burdens associated with the upstream life cycle stage.
[Figure by the authors.]

industry, the total annual value of each type of building for which permits were issued would be an indication of not only the total number of each building type constructed each year, but also the relative extent of environmental impact associated with each building type.

A review of building permits issued by the City of Seattle for five-years (each year from 1996-2000) revealed that the total average annual construction value of single-family residential building was about $100 million and the total average value of office and commercial building was about $300 million. (Most non-residential and non-industrial buildings listed in the permit records were mixed-use, i.e., not solely office nor commercial but some percentage of both.) If associated upstream environmental burdens can be correlated to economic value, then, for any given year, office/commercial buildings will usually have greater total environmental impact than residential (single family) building construction.

Thus, future City of Seattle policies and practices to mitigate impact to salmon habitat may focus to a greater extent on office, retail and multi-family building construction rather than single-family residential construction. However, this may not be true for particular industry types or specific building materials or products. For example, in the case of interior walls and partitions, office and commercial building projects typically specify metal (usually steel) framing components whereas residential projects usually specify wood framing products. Overemphasis on office and commercial construction could therefore underestimate the upstream environmental impact of wood materials and products used in residential construction.

In the results discussed in Sections A4.3 and A4.4 of this report, environmental burdens associated specifically with office and commercial building types are highlighted in the "2nd tier" of the summary tables. This format will aid in the identification of high priority upstream inputs to construction that are unique to office and commercial buildings.

Outside the City of Seattle, the relative proportions of the three different building types might vary. Suburban and rural areas on the city fringe, for example, may contain a higher percentage of residential type construction (by both cost and area) than is found in the city limits. Therefore, the focus of suburban and rural policies and practices may be more on single-family residences. (The amount of construction activity for each of the three building types for areas outside the City of Seattle was not investigated for this report.)

In the results discussed in sections A4.3 and A4.4 of this report, environmental burdens associated specifically with single-family residential buildings are highlighted in the "3rd tier" of the summary tables. This format will aid in the identification of high priority upstream inputs to construction unique to single-family residences.

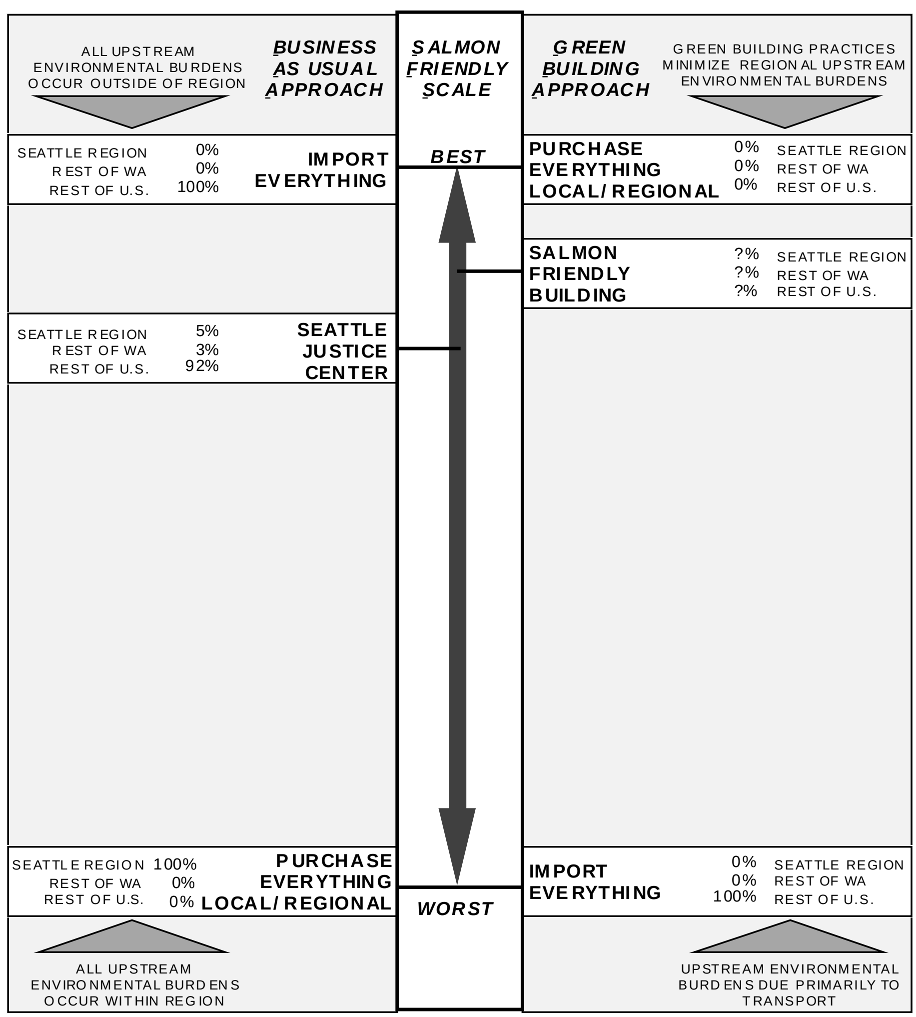
2.5 Upstream Environmental Impacts: Various Building Scenarios

Since the manufacture of any given building material or product results in some negative environmental impacts, importing all building materials and products from outside the region shifts all associated upstream supply chain environmental burdens to areas outside the Seattle metropolitan region – to the rest of Washington state and the rest of U.S. In a "business-as-usual" design and construction approach to buildings, this "import-everything" scenario is the process with the least environmental impact on salmon habitat in the Seattle region and is therefore, the most "salmon-friendly." (See the left side – 'Business-as-Usual Approach' – in Figure A2.5.1.)

For "business-as-usual" design and construction of a new office/commercial building in the City of Seattle (Case Study: Seattle Justice Center), upstream external environmental impacts occur primarily outside the metropolitan area (King County) and state of Washington. This condition is due to the type of jobs that are being supported in each of the nested regions. Inside the county and state there are few manufacturing jobs but many less polluting jobs created in the construction sector. Manufacturing, which occurs primarily outside the county and state, is the dominant source of air pollution in the life cycle of inputs to construction due to its high emissions per dollar of output. Additionally, manufacturing is less labor intensive than construction due to the fact that there is more automation usually associated with manufacturing. Thus, this "real-life" example is very close to the "import-everything" scenario described above. Most upstream environmental burdens occur outside the region and will not affect salmon habitats in the Seattle area.

Figure A2.5.1: Various Upstream Environmental Burden Scenarios

In a "Business-as-Usual" approach, importing all building materials and products shifts all the upstream environmental burdens outside the region. Thus, the "import everything" scenario is the most "salmon-friendly." In the case of the SJC project, almost all materials and products were imported and the associated upstream environmental burdens occurred outside the region. The "purchase everything locally and regionally" scenario is the least salmon-friendly" since all associated upstream environmental burdens occur in the region. Under a "Green Building" approach, the ideal condition is the "purchase everything locally and regionally" scenario with zero associated upstream environmental burdens. How close to this ideal is a "salmon-friendly" building?
[Figure by the authors.]



At the bottom of the "Business-as-Usual" spectrum, purchasing all building materials and products from within the region shifts all associated upstream supply chain environmental burdens to areas inside the Seattle metropolitan area. In such a "purchase everything locally and regionally" design and construction approach to buildings, the greatest environmental impact on salmon habitat occurs in the Seattle region and is therefore, the least "salmon-friendly."

Although it may be the most "salmon-friendly" under a "Business-as-Usual" scenario, the "import-everything" scenario is incompatible with a "buy local" approach common to "green building" program recommendations. The "buy local" approach attempts to reduce environmental impacts due to long distance transport of building materials and products while simultaneously stimulating the local economy and employing the local labor force. The ideal scenario is to "purchase everything locally and regionally" with zero upstream environmental impact. (See the right side - 'Green Building Approach' - in Figure A2.5.1.) One question posed by the BaselineGreen™ analysis is how close to this ideal, realistically, can be the definition of a salmon-friendly building?

One step in achieving this ideal is to analyze regional upstream environmental burdens at the level of individual inputs to construction in order to promote business activities in the construction sector that have the least external environmental cost. Conversely, one hopes to avoid selecting building material and/or product types associated with high local and regional environmental burdens.

A3.0 Methodology

Environmental Life Cycle Assessment (LCA) is an approach to the systematic and quantitative study of the upstream and downstream environmental implications of products. Life Cycle Assessments can be conducted using either process-level modeling, or industry/commodity level input/output modeling. This study utilizes the latter approach and limits its scope to only the upstream (or "embodied") environmental consequences of the full set of hundreds of inputs required for a building project. The project input set is fully comprehensive and includes inputs of raw materials, energy, equipment, fabricated products, intermediate products, and services.

By "upstream", we mean all those processes whose outputs are used directly or indirectly to support an activity of interest. Another word for an activity's family of upstream processes is its "supply chain." Theoretically the chain of suppliers is infinite, since all suppliers in turn have their own suppliers. However, we have found from empirical experience that after approximately six to eight supply tiers, the share of total upstream productive output added by additional tiers becomes negligible. This result is in turn caused by the fact that, by definition, the total value of the inputs to a (economically viable) production process must be less than the value of its output.

The BaselineGreen™ analysis makes extensive use of detailed U.S. input/output data from the Bureau of Economic Analysis (BEA) together with federal data on pollution releases by sector from the U.S. Environmental Protection Agency (EPA) and federal data on fuel-specific energy consumption by sector from the U.S. Department of Energy's Energy Information Administration (EIA).

The BEA 1992 detailed Input/Output Accounts provide a starting point for modeling inter-industry flows. The BEA's "Make" and "Use" tables are used directly in our analysis to enable tier-by-tier assessment of results. We retained 498 industries from the BEA tables, including government enterprises such as the US Postal Service, and the 488 BEA commodities produced by these industries. For most manufacturing industries, the BEA industries and commodities match the U.S. four-digit Standard Industrial Classifications (SICs) one-for-one. Outside of manufacturing, some BEA industries represent aggregations of 4-digit SICs, while other BEA industries are composed of portions of one or more 4-digit SICs.

Many establishments in the economy manufacture more than one type of product. This product diversity is even more pronounced among the full set of establishments classified within a single SIC category. The industries and commodities are created by BEA in order to provide a characterization of the inputs and outputs of more homogeneous producing units than those which would arise from developing and publishing the tables on a purely SIC basis - that is, simply using the total production and consumption data for all establishments which are assigned to each SIC as the basis for defining industries as SICs.

Next, fuel-specific energy consumption data (in Btu per dollar of sectoral output) was integrated into the system. The U.S. Census of Mining reports fuel-specific energy consumption for the mining industries. 1992 Census of Mining data were used in this analysis. Electricity consumption in kWh is also reported for all manufacturing industries (by 4-digit SIC) by the 1992 Census of Manufacturing, as is cost of other purchased fuels. Note that not all purchased fuels are actually combusted; some are used as feedstocks to product production, as in the use of petrochemicals as feedstocks in manufacturing plastics or fertilizers.

The EIA conducts biennial surveys of manufacturing industry energy consumption, by fuel and end-use, and reports both costs and quantities in energy units. The EIA data reports the quantities of each fuel that is combusted. Data for fuel combustion from the 1991 Manufacturing Energy Consumption Survey (MECS), reported EIA 1994, were used in the present analysis.

Fuel-specific manufacturing energy combustion data and the fuel-specific census of mining energy consumption data were converted to provide fuel-specific consumption totals by BEA industry. For nearly all manufacturing industries, the mapping from four-digit SIC to BEA industry is one-to-one; in a few cases, multiple SICs are assigned to a single BEA industry.

For the major energy consuming sectors, MECS reports fuel-specific combustion by four-digit SIC. For sectors that consume smaller amounts of energy, MECS reports fuel-specific combustion by 3-digit or 2-digit SIC. These fewer-digit SICs consist of multiple 4-digit SICs. In these cases, the (1991) MECS-reported fuel shares fuel prices for an aggregated sector were combined with the (1992) Economic Census-reported total cost of fuels for each detailed sector, in order to derive estimated fuel-specific combustion quantities by detailed sector. The total fuel-specific combustion within each 2-digit and 3-digit sector will match those reported by MECS.

EIA also reports fuel-specific sectoral prices for the following non-manufacturing sectors: residential & commercial, industrial, transportation, and electric utilities. These prices (for 1992, concurrent with the BEA consumption data in the Input/Output accounts) were used to convert the non-manufacturing BEA industry fuel and electricity consumption data from dollars to energy units, reported by the EIA in1993.

Finally, fuel-specific sectoral energy combustion data were used to calculate fossil fuel-based carbon emissions by sector, using the fuel-specific carbon emissions coefficients at full combustion provided by the EIA in 1995. These emissions were converted from metric tons of carbon to metric tons of CO_2, and were then divided by each sector's 1992 value of product output to obtain CO_2 emission intensities, in units of metric tons of CO_2 per dollar of 1992 product output.

Data from the EPA's Toxic Release Inventory were obtained for 1999 releases to each media by each 4-digit SIC. These data were mapped to the BEA industries, developing total releases to water and to air per BEA industry per dollar of product output (in producer's prices). These data are used in upstream analyses of the toxic release burdens of building products.

The first step in the BaselineGreen™ analysis process is to define in detail a "baseline building" using typical BEA data for 40 building types that accurately typifies the subject building in the design stages of a project. Initially, only a building's area, mix of spatial uses, and estimated construction cost need to be determined. This baseline building definition provides the means of generating a bill of materials and their costs which is tailored to the specific building project and which is derived from data for the U.S. construction sector as a whole. This bill of materials typically contains hundreds of items. Subsequently, each "input to construction" item in the bill of materials is analyzed using I/O-LCA methods in order to estimate the total releases of 14 different types of pollution associated with manufacturing and supplying the required quantity of each input item.

In this report, the upstream building-related environmental burden results are presented from three different BaselineGreen™ analyses. The first BaselineGreen™ analysis conducted an Input Environmental Importance Analysis (simultaneous upstream life cycle assessment of all inputs) for three separate types of new construction: new single-family residential construction, new commercial construction, and new office building construction. Each construction type is described in terms of the input requirements of average U.S. construction for that building type in 1992 (the latest year for which this detailed data are available from the Federal Government).

Second, based upon previous work under contract with the City of Seattle, the Seattle Justice Center (SJC) project is presented as an example of new mixed-use office and commercial building construction under a typical "business-as-usual," national input-output model. In this example, almost all building inputs to construction are purchased from manufacturers outside the three-county Seattle metropolitan region. Consequently, the upstream environmental burdens associated with the manufacture of the materials and products specified for the building also originate outside the region. The environmental burdens associated with the small amount of inputs originating within the region are analyzed in detail however, for in the case of any given salmon habitat, even a relatively minute quantity of toxic releases can have a devastating impact.

A third BaselineGreen™ analysis examined the hypothetical case where almost all building inputs to construction for all three building types are purchased from local and regional manufacturers within the three-county Seattle metropolitan region (i.e., a regional input-output model). In this way, the relative magnitude of upstream environmental burdens originating from all local and regional building-related manufacturing was assessed. This model still generates upstream environmental burdens outside the region however, because the supply chain of activities for any given material or product extends beyond regional political boundaries.

These three BaselineGreen™ analyses examined three environmental burden indicators – criteria air pollutants, greenhouse gases, and total toxic releases – for all building-related manufacturing industries categorized by the U.S. Bureau of Economic Analysis (BEA). Criteria air pollutants include nitrogen oxides, sulfur dioxide, particulate matter, volatile organic compounds (VOC's), and carbon monoxide. Greenhouse gases are dominated by CO2. Toxic releases may be one of over 500 chemicals ranging from ammonia to zinc. The BEA categories are similar to the Standard Industrial Classification (SIC) manufacturing industry classification system. The SIC classification system covers the entire field of economic activity in the U.S. It groups industries by Divisions (e.g., mining or manufacturing), Major Groups (e.g., lumber and wood products) and sub-groups (e.g., sawmills and planing mills). For example, BaselineGreen™ results are presented for an entire group of related manufacturing facilities such as ”sawmills and planning mills” and “glass and glass products” which can be correlated with SIC sub-group categories.

In all three analyses, the total impact of each of the three environmental burdens is estimated on the basis of the cost (as representing quantity) of an input to construction into the building relative to the total cost of that input to construction in the entire U.S. The BaselineGreen™ methodology proportions the upstream environmental burdens of a BEA input item for a particular building based on the annual value of all economic activity associated with that particular BEA input item. For example, if “$ x” million of industrial activity for all steel mills in the U.S. resulted in “z” pounds of air pollution in the entire U.S., and if for a particular building project, 1% of “$ x” was the cost of steel mill products in the building, then the air pollution burden for that building is assumed to be 1% of “z” pounds. Thus, the environmental burden of each BEA input to construction in a building project is scaled to its share of the total national cost of all activity for that input to construction.

It is very important to note that BaselineGreen™ establishes a baseline derived from national average data, and is best conceptualized as a tool for narrowing the search for environmental impacts, or as a tool that flags specific types of industries based on their emissions. Thus after the BaselineGreen™ analysis, further research was conducted to determine how the flagged building related industries in the KPS region or in the state compared to the national industry average relative to emissions. See Section A4.6 for more explanation regarding Baseline Green™ and emissions. Following the three BaselineGreen™ analyses, 1997 and 1999 toxic release inventory data for the State of Washington were reviewed in an attempt to detect and locate specific facilities identified by SIC sub-groups as contributing a significant share of one or more of the three environmental burden indicators. For example, the SJC Project BaselineGreen™ analysis indicated that for material and product inputs originating from the King County region, of all toxic releases within the county, the industry sub-group “wood kitchen cabinets” accounted for about 30% of the total, the highest of all upstream building-related manufacturing industries in the county. A search of toxic release inventory data for King County revealed that a number of manufacturers of wood kitchen cabinets are located in the region. Their toxic release reports were reviewed and their manufacturing facilities were located. Similar findings for other major “high-burden” SIC sub-groups are presented in this report.

Following the toxic release data review, recommendations are made for the selection of environmentally and economically preferred material and product types among many input to construction options.

A4.0 Findings

A4.1 BaselineGreen™ Analysis 1: Model of Environmental Burdens Associated with Average U.S. New Construction of Three Building Types

In the analysis of upstream inputs to average U.S. new construction for three building types, the major building-related upstream manufacturing industries contributing the highest share of environmental burdens are listed in Tables A4.1.1, A4.1.2, and A4.1.3 below. These are cost share burdens, i.e., burdens associated with inputs that account for highest share of total construction cost of all inputs. (Note that total toxic releases have been separated into two categories – toxic releases to water and toxic releases to air.)

Table A4.1.1: Building-Related Industries in the U.S. Contributing the Highest Share (≥ 2%) of Upstream Environmental Burdens for <u>New Residential Construction</u>

Toxic Releases to Water (TRIW)		Toxic Releases to Air (TRIA)		Air Pollution (CAP)		Greenhouse Gases (GHG)	
Hardwood and softwood lumber	7%	Wood kitchen cabinets	8%	Ready-mixed concrete	9%	Ready-mixed concrete	9%
Interior and exterior paints	5%	Mineral wool	8%	Cement, hydraulic	5%	Mineral wool	5%
Hay	5%	Interior and exterior paints	6%	Mineral wool	4%	Cement, hydraulic	4%
Millwork	5%	Bldg. fabricated plastic products	4%	Crushed and broken stone	4%	Millwork	3%
Softwood plywood products	4%	Waferboard and osb	4%	Millwork	3%	Paving mixtures and blocks	3%
Waferboard and osb	3%	Millwork	3%	Solvent and water type paints	3%	Waferboard and osb	3%
Bldg. fabricated plastic products	3%	Bldg. plastic products	3%	Hardwood and softwood lumber	2%	Interior and exterior paints	2%
Wood kitchen cabinets	2%	Plastic plumbing fixtures	2%	Waferboard and osb	2%	Crushed and broken stone	2%
Sawmills and planning mills	2%	Non-current carrying devices	2%	Softwood plywood products	2%	Structural shapes, piling, rein. Bars	2%
Wallcoverings	2%	Unitary air conditioners	2%	Paving mixtures and blocks	2%	Concrete block and brick	2%
Tufted carpets, rugs, artificial grass	2%			Gypsum building materials	2%	Wood kitchen cabinets	2%
Mineral wool	2%			Concrete block and brick	2%	Construction sand and gravel	2%
Rough and dressed lumber, treated	2%			Wood kitchen cabinets	2%	Gypsum building materials	2%
Bldg. plastic products	2%			Bldg. fabricated plastic products	2%	Bldg. fabricated plastic products	2%
Ready-mixed concrete	2%			Structural shapes, piling, rein. bars	2%	Hardwood and softwood lumber	2%
Hardwood plywood	2%						
Plastic plumbing fixtures	2%						

Table A4.1.2: Building-Related Industries in the U.S. Contributing the Highest Share (≥ 2%) of Upstream Environmental Burdens for <u>New Office Construction</u>

Toxic Releases to Water (TRIW)		Toxic Releases to Air (TRIA)		Air Pollution (CAP)		Greenhouse Gases (GHG)	
Solvent and water type paints/coatings	6%	Solvent and water type paints	6%	Cement, hydraulic	6%	Cement, hydraulic	4%
Hard surface floor coverings	6%	Hard surface floor coverings	6%	Ready-mixed concrete	4%	Ready-mixed concrete	4%
Hay	4%	Wood kitchen cabinets	5%	Hard surface floor coverings	4%	Fabricated struct. iron, steel, alum.	4%
Hardwood and softwood lumber	4%	Bldg. fabricated plastic products	4%	Nonferrous wire and cable	4%	Hard surface floor coverings	4%
Millwork	4%	Environmental controls	3%	Fabricated struct. iron, steel, alum.	3%	Solvent and water type paints/coatings	3%
Softwood plywood products	3%	Fabricated struct. iron, steel, alum.	3%	Solvent and water type paints/coatings	3%	Nonferrrous wire and cable	2%
Fabricated struct. iron, steel, alum.	3%	Nonferrous wire and cable	3%	Millwork	2%	Elevators and moving stairs	2%
Bldg. fabricated plastic products	2%	Comm./ind. metal doors and frames	2%	Comm./ind. metal doors and frames	2%	Comm./ind. metal doors and frames	2%
Sawmills and planning mills	2%	Millwork	2%	Other glass products	2%	Millwork	2%
Hardwood flooring	2%	Bldg. Plastics products	2%	Elevators and moving stairs	2%	Other glass products	2%
Wood kitchen cabinets	2%	Elevators and moving stairs	2%	Sheet metal work	2%	Sheet metal work	2%
Rough and dressed lumber, treated	2%	Unitary air conditioners	2%	Custom roll form products	2%	Custom roll form products	2%
Nonferrrous wire and cable	2%	Sheet metal work	2%	Gypsum building materials	2%		
		Partitions and fixtures, exc. Wood	2%				

Table A4.1.3: Building-Related Industries in the U.S. Contributing the Highest Share (≥ 2%) of Upstream Environmental Burdens for <u>New Commercial Construction</u>

Toxic Releases to Water (TRIW)		Toxic Releases to Air (TRIA)		Air Pollution (CAP)		Greenhouse Gases (GHG)	
Prefab metal building systems	7%	Prefab metal building systems	9%	Prefab metal building systems	8%	Prefab metal building systems	9%
Hardwood and softwood lumber	7%	Interior and exterior paints	5%	Cement, hydraulic	5%	Cement, hydraulic	4%
Interior and exterior paints	5%	Wood partitions and fixtures	3%	Fabricated struct. iron, steel, alum.	3%	Fabricated struct. iron, steel, alum.	4%
Millwork	5%	Millwork	3%	Nonferrous wire and cable	3%	Other glass products	3%
Hay	4%	Fabricated struct. iron, steel, alum.	3%	Asphalt felts and coatings	3%	Asphalt felts and coatings	3%
Softwood plywood products	4%	Comm/ind. metal doors and frames	3%	Other glass products	3%	Millwork	2%
Sawmills and planning mills	3%	Bldg. Fabricated plastic products	2%	Millwork	3%	Gypsum building materials	2%
Fabricated struct. iron, steel, alum.	3%	Nonferrous wire and cable	2%	Gypsum building materials	2%	Comm/ind. metal doors and frames	2%
Rough and dressed lumber, treated	2%	Bldg. plastic products	2%	Comm/ind. metal doors and frames	2%	Solvent and water type paints/coatings	2%
Bldg. Fabricated plastic products	2%	Elevators and moving stairs	2%	Solvent and water type paints/coatings	2%	Custom roll form products	2%
		Other glass products	2%	Hardwood and softwood lumber	2%	Elevators and moving stairs	2%
				Elevators and moving stairs	2%	Nonferrous wire and cable	2%
				Ready-mixed concrete	2%	Metal awnings, canopies, cornices	2%
				Softwood plywood products	2%		

Cost share industry groups that consistently appear in each of the three lists of average U.S. new construction for three building types are shown in the first tier summary list in Table A4.1.4 below. Additional industry groups appearing in lists for office and commercial building types are included in the second tier.

Upstream inputs to construction for a building project located in Seattle originate from manufacturers and suppliers from all over the nation (and the world). An analysis of upstream industrial inputs to an average of all U.S. buildings of a particular type therefore, gives us a clue as to which input items might be the highest in terms of associated upstream environmental burdens for the same building type constructed in the Seattle region.

Table A4.1.4: Building-Related Upstream Manufacturing Industries Contributing the Highest Share of Environmental Burdens for Three Types of New Construction in the U.S. – Residential, Office, and Commerecial

Toxic Releases to Water (TRIW)	Toxic Releases to Air (TRIA)	Air Pollution (CAP)	Greenhouse Gases (GHG)
1st Tier: All Three Building Types			
Hay	Millwork	Millwork	Millwork
Hardwood and softwood lumber	Building fabricated plastic products	Cement, hydraulic	Cement, hydraulic
Sawmills and planning mills	Building plastic products	Ready-mixed concrete	Ready-mixed concrete
Softwood plywood products	Solvent and water type paints	Gypsum building materials	Fabricated structural iron, steel, aluminum
Rough and dressed lumber, treated		Solvent and water type paints	Solvent and water type paints
Millwork			
Building fabricated plastic products			
Solvent and water type paints			
2nd Tier: Additional High Share Inputs for Office and Commercial Building Types			
Wood kitchen cabinets	Wood kitchen cabinets	Hardwood and softwood lumber	Commercial/industrial metal doors and frames
Hardwood flooring	Fabricated structural iron, steel, aluminum	Softwood plywood products	Sheet metal work
Fabricated structural iron, steel, aluminum	Sheet metal work	Fabricated structural iron, steel, aluminum	Custom roll form products
Nonferrous wire and cable	Commercial/industrial metal doors and frames	Sheet metal work	Prefab metal building systems
Hard surface floor coverings	Prefab metal building systems	Commercial/industrial metal doors and frames	Nonferrous wire and cable
	Nonferrous wire and cable	Prefab metal building systems	Asphalt felts and coatings
	Hard surface floor coverings	Nonferrous wire and cable	Gypsum building materials
	Other glass products	Hard surface floor coverings	Other glass products
	Elevators and moving stairs	Asphalt felts and coatings	Elevators and moving stairs
	Environmental controls	Other glass products	
	Unitary air conditioners	Elevators and moving stairs	

Table A4.1.4 indicates that for toxic releases to water, high priority items by building cost share for average U.S. construction of the three building types are mainly the following:

For all three building types:
- Hay (apparently due to heavy pesticide use),
- Wood products, rough and finished (such as lumber, plywood, and millwork),
- Solvent and water-based paint products,
- Fabricated plastic products.

For office and retail building types:
- Wood products, finished (flooring and cabinets),
- Fabricated structural metal products,
- Wire,
- Floor coverings.

For toxic releases to air, wood product industries play a lesser role and metal products play a larger role, especially for office and commercial building types. Fabricated metal products are used in office and commercial type buildings more than in residential type buildings.

Again, for criteria air pollutants and greenhouse gases, except for millwork, wood product industries play a lesser role. The high priority items are not metal, but primarily non-metallic mineral-based products. These include products purchased from the following industries:

- Cement,
- Ready-mixed concrete,
- Gypsum building products.

Paint products appear as high priority input item to all three building types. Fabricated metal products, glass products, and mechanical and electrical equipment for buildings are typically a high cost share input item for office and commercial building types.

In summary, the building related industries listed in Table A4.1.4 represent an inventory of “high priority” input items associated with upstream environmental burdens for average construction activity in the U.S. of three building types – residential, office, and commercial. Because a building project located in the Seattle region will typically include inputs to construction from all over the U.S., this list will be compared to the results for an office/commercial building project located in the City of Seattle.

A4.2 BaselineGreen™ Analysis 2: A Typical Mixed-Use Office/Commercial Building (the Seattle Justice Center Project)

In a typical “business-as-usual” design and construction scenario for office, commercial, or mixed-use buildings, a majority of building materials and products are provided from a national and international list of manufacturers and suppliers. A BaselineGreen™ analysis provides the ability to apportion the upstream external environmental cost impacts of the inputs to construction to three nested geographic regions within which the Seattle Justice Center (SJC) project is located. In this case those three nested regions are King County, the state of Washington except King County, and the rest of the U.S. except Washington.

In the case of the SJC project, the manufacturing of a large majority of building materials and products and associated environmental burdens occurred outside the Seattle metropolitan area and outside the state of Washington. These data indicate that there exists opposing trends relative to the occurrence of upstream external environmental costs and job related economic impacts. Upstream external environmental impacts occur primarily outside the metropolitan area (King County) and state of Washington. This condition is due to the type of jobs that are being supported in each of the nested regions. Inside the county and state there are few manufacturing jobs but many less polluting jobs created in the construction sector. Manufacturing, which occurs primarily outside the county and state, is the dominant source of air pollution in the life cycle due to its high emissions per dollar of output. Additionally, manufacturing is less labor intensive than construction due to the fact that there is more automation usually associated with manufacturing.

By far the largest share of the total upstream air pollution associated with the SJC project occurs outside of King County and outside of the state of Washington, as shown in the Table A4.2.1 below. The "rest of U.S." share ranges from 75% to 96%, depending upon the air pollutant. The "rest of US" share accounts for 86% of the total economic cost of the criteria air pollutants including carbon dioxide.

Depending upon the air pollutant selected, the share of upstream air pollution occurring in King County ranges from 3% to 16%. King County accounts for 9% of the total economic cost of the criteria air pollutants including carbon dioxide.

The smallest share of the upstream air pollution emissions associated with the SJC project falls in the state of Washington, outside of King County. This share ranges from 1% to 10%, depending upon the air pollutant. Washington accounts for 5% of the total economic cost of the criteria air pollutants including carbon dioxide.

Table A4.2.1: Total Upstream Air Pollution and Toxic Releases for the SJC Project Sorted by Region

Region	VOC (lbs)	NOx (lbs)	CO (lbs)	SO2 (lbs)	PM10 (lbs)	CO2 (lbs)	TRIE (lbs)	Air Pollution Cost ($)
King County	3650	3959	8075	2152	4082	1636211	1337	$ 159,574
Rest of WA	2469	2392	3650	779	2465	350032	857	$ 81,289
Rest of US	32910	24408	143776	64921	19397	14327273	23576	$ 1,449,024
Total	39029	30759	155502	67852	25944	16313516	25770	$ 1,689,887
Pollutant Percentages by Region								
King County	9%	13%	5%	3%	16%	10%	5%	9%
Rest of WA	6%	8%	2%	1%	10%	2%	3%	5%
Rest of US	84%	79%	92%	96%	75%	88%	91%	86%

Upstream (supply chain) toxic releases to water, land, and air have been previously mentioned as the building related environmental factors most directly affecting salmon habitats. As Table A4.2.1 indicates, for the SJC baseline building definition, only 8% of all upstream toxic releases to the environment (TRIE) occur in the state of Washington.

Consequently, an examination of inputs to construction originating in the state of

Table A4.2.2: Manufacturing Industries in King County Contributing the Highest Share (≥ 1%) of Upstream Environmental Burdens for the SJC Project

Total Toxic Releases		Air Pollution		Greenhouse Gases (CO2)	
Wood kitchen cabinets	30%	Sawmills and planing mills	50%	Glass and glass products	10%
Millwork	14%	Glass and glass products	9%	Sawmills and planing mills	8%
Metal partitions and fixtures	9%	Millwork	6%	Metal partitions and fixtures	2%
Glass and glass products	4%	Wood kitchen cabinets	2%	Millwork	1%
Adhesives and sealants	4%	Blast furnaces and steel mills	1%	Blast furnaces and steel mills	1%
Refrigeration and htg. equip.	3%	Adhesives and sealants	1%	Structural wood members	1%
Automatic temp. controls	3%	Wood products, nec	1%	Wood kitchen cabinets	1%
Wood partitions and fixtures	3%	Metal partitions and fixtures	1%	Pipes, valves, pipe fittings	1%
Fabricated metal prod., nec	2%	Veneer and plywood	1%	Adhesives and sealants	1%
Pipes, valves, pipe fittings	2%	Gypsum products	1%		
Misc. fabricated wire prod.	2%	Refrigeration and htg. equip.	1%		
Elevators/moving stairways	2%				
Structural wood members	1%				
Reconstituted wood products	1%				
Blast furnaces and steel mills	1%				
Metal doors, sash, trim	1%				
Wood products, nec	1%				
Steel wire and related prod.	1%				
Fabricated structural metal	1%				

Table A4.2.3: Manufacturing Industries in the Rest of the State of Washington Contributing the Highest Share (≥ 1%) of Upstream Environmental Burdens for the SJC Project

Total Toxic Releases		Air Pollution		Greenhouse Gases (CO2)	
Wood preserving	25%	Veneer and plywood	45%	Veneer and plywood	16%
Hardwood dimension/ flooring	20%	Hardwood dimension/flooring	17%	Wood preserving	12%
Veneer and plywood	12%	Wood preserving	6%	Asphalt felts and coatings	10%
Millwork	8%	Sawmills and planing mills	5%	Hardwood dimension/ flooring	5%
Wood kitchen cabinets	7%	Millwork	4%	Reconstituted wood products	2%
Reconstituted wood products	3%	Asphalt felts and coatings	3%	Glass and glass products	2%
Fabricated metal prod., nec	3%	Wood products, nec	1%	Millwork	2%
Refrigeration and htg. equip.	2%	Glass and glass products	1%	Sawmills and planing mills	2%
Prefab metal buildings	2%	Wood kitchen cabinets	1%	Refrigeration and htg. equip.	1%
Metal partitions and fixtures	1%			Prefab metal buildings	1%
Fabricated structural metal	1%			Fabricated structural metal	1%
Wood products, nec	1%			Fabricated metal prod., nec	1%
				Sheet metal work	1%

Washington will address only a small percentage of the total TRIE releases associated with all inputs to the SJC project. However, due to geographic location, these are the inputs that most directly impact salmon habitat.

Similarly, five air pollutants and one greenhouse gas emission occurring in the state of Washington represents only a small percentage - 14% - of the total releases. Air pollutants and greenhouse gases, however, have a less direct impact on salmon habitat. In fact, due to airshed patterns of atmospheric deposition, air pollution and greenhouse gases originating from outside the region may actually have a more direct impact than air pollution originating from within the region.

Next, upstream external environmental burdens can be examined by industry groups or inputs to construction for those items that account for the bulk of each of the three environmental burdens in each region. Notably, different industry groups dominate the environmental burden in each of the three regions.

In King County, “wood kitchen cabinets,” “sawmills and planing mills,” and “glass and glass products” top the list of environmental burdens for total toxic releases, air pollutants, and greenhouse gases respectively. For the rest of the state of Washington, “wood preserving” and “veneer and plywood” top the lists, with “hardwood, dimension and flooring” listed as a close second for total toxic releases. A summary of the manufacturing industry groups with the highest contribution to regional upstream air pollution is presented for King County and the rest of the state of Washington in Tables A4.2.2 and A4.2.3.

As mentioned above, BaselineGreen™ links the share of environmental burdens associated with an industry group or input item to the cost of materials and/or products provided by that group or input item in the baseline building type. The environmental burdens are linked to the average dollar value of each item in an average building of this type. Thus, the Tables A4.2.2 and A4.2.3 indicate by building cost share, those items that have the highest burdens. For example, the input item “veneer and plywood” appears at the top of each column is that it represents by cost a larger percentage of inputs than any other item lower in the list.

These rankings will change based on the cost of the emissions. For every dollar of a specific input item into the building, what is the corresponding cost in air pollution? Numerous private and government studies have estimated the “external” costs of air pollution to society in terms of the actual dollars spent on environmental impacts such as health care costs that can be linked to particular pollutants. The approach taken in this report is to employ a set of outlier-corrected higher end dollar values (roughly between centrally tending values and high end extremes) for criteria air pollutants and greenhouse gases combined into a single average value shown in Table A4.2.4 (see sidebar).

The values for external costs of air pollutants and greenhouse gases found in Table A4.2.4 were used to determine the monetary value of a particular upstream environmental burden associated with each input to construction. This monetary value can be expressed as a ratio. The units of the ratio are external cost of upstream environmental burden in dollars per million (or thousand, hundred, etc.) dollars of the market cost of the input to construction. We have called this ratio the “external environmental cost ratio” (EECR) for

Table A4.2.4: Mean of Outlier-Corrected High Values for External Costs of Various Air Pollutants

Air Pollutant	Mean External Cost High Value (Dollars per Ton of Pollutant)
NOx	$16,900
VOCs	$10,100
CO	$2,900
PM10	$26,500
SO2	$10,600

each input to construction. It can be expressed as the following:

$$\text{EECR} = \frac{\text{upstream external environmental cost of input to construction}}{\text{market cost of input to construction}}$$

When this ratio is applied at the level of inputs to construction, we derive the upstream external environmental cost of the more than 200 generic inputs to construction of the building. For any input to construction, if both the EECR and the cost are known, then the total upstream environmental burden for any input to construction in monetary terms can be expressed as:

upstream external environmental cost of input to construction
= EECR x market cost of input to construction

In Table A4.2.5 (see sidebar), the upstream external environmental cost for high priority inputs to construction is listed in the right hand column. The EECR can be used to determine which inputs to construction within product categories have the highest per dollar upstream external environmental cost. For example, in the category Interior Finishes, "tufted carpets" has an EECR of 0.24 meaning that for every $1.00 of market cost, $0.24 is generated in upstream external environmental cost. Compare that with "ceramic wall and floor tile" which has an EECR of 0.17 meaning that $0.17 of upstream external environmental cost is generated for each $1.00 of market cost. Dollar for dollar, tufted carpets have 40% greater upstream external environmental cost than ceramic tile.

In the SJC project as a whole, the market cost of tufted carpet is $1,021,000 generating over $245,000 of upstream external environmental cost. The market cost of ceramic tile is $203,700 generating almost $35,000 of upstream external environmental cost.

Of course, the total upstream external environmental cost for any input to construction has to be adjusted according to the unit cost of that input to construction. In the example above, if the unit cost of ceramic tile is higher than the unit cost of tufted carpet, then the cost difference must be accounted for in determining the upstream external environmental cost in providing a floor finish for a particular area. For example, for a 1,000 square foot room, assume that the materials cost of the tufted carpet is $4.00/sf and the ceramic tile is $6.00/sf. The market cost for the floor finish for that room is $4,000 for tufted carpet and $6,000 for ceramic tile. Multiplying each total market cost by the appropriate EECR yields an upstream external environmental impact of $960 for the tufted carpet and $1,020 for the ceramic tile. Therefore, for this particular application or floor area, the upstream external environmental impacts are nearly equal. (This method of determining the actual upstream external environmental cost for the SJC building is described in greater detail in Section A2.0 of this report.)

What Table A4.2.5 indicates is that per dollar of product, the non-metallic mineral-based products (cement, concrete, gypsum, brick) have the highest upstream environmental impacts for air pollution. They are followed by metal products (especially structural and fabricated steel). Wood products are near the bottom of the list – lumber, structural wood, millwork, and wood cabinets.

As indicated in Tables A4.2.2, A4.2.3, and A4.2.5, per unit ranking of upstream environ-

Table A4.2.5: Summary List of Air Pollution EECR for High Priority Inputs to Construction Located in the State of Washington (Ranked by EECR)

Inputs to Construction by Industry Classification	EECR Cost per $
Cement, hydraulic	2.22
Gypsum building materials	0.63
Structural shapes, sheet piling, and concrete reinforcing bars	0.61
Ready mix concrete	0.49
Brick and structural clay tile	0.41
Concrete block and brick	0.38
Fabricated bar joists and concrete reinforcing bars	0.34
Wallcoverings	0.28
Other glass products including tempered, multiple glazed, & stained	0.26
Interior and exterior architectural solvent and water type paints and coatings	0.25
Commercial and industrial metal doors and frames	0.24
Residential metal doors and frames	0.24
Metal flooring and siding	0.24
Building and construction plastic foam products	0.24
Tufted carpets, rugs, and artificial grass	0.24
Fabricated structural iron, steel, aluminum for buildings	0.23
Fabricated structural metal, nec	0.23
Other fabricated structural metal	0.23
Other granite products including building stone	0.23
Marble building stone, monument tone, and other marble products	0.23
Softwood plywood products, rough, sanded, and specialties	0.23
Hard surface floor coverings	0.23
Hardwood flooring and hardwood dimension lumber and flooring	0.20

mental burdens differs significantly from share of building cost rankings. Some building materials and products are associated with high upstream environmental burdens for a particular building simply because they typically represent a high percentage of the building cost, and therefore, by inference, of the content or volume of all materials and products used in the building. However, there are numerous low cost share materials and products that per unit (by weight, volume, or dollar) have greater upstream environmental burdens than the high cost share input items.

Therefore, to reduce upstream environmental burdens, guidelines should include both high volume/cost share input items and high EECR input items. Industry groups can be sorted either or both ways - by degree of impact due to building cost share/volume and by impact per unit of product cost. Table A4.2.6 (see sidebar this page) lists air pollution burdens for high priority inputs to construction located in the state of Washington ranked by both building cost share and by unit cost of the product (EECR). Note that the lists are quite different. Whereas the highest building cost share input items are primarily wood related products, glass products, and asphalt products, the highest per unit EECR input items are primarily non-metallic mineral (mined) products and steel products.

Two important inputs to construction do not appear on the building cost share list in Table A4.2.6. Even though "ready-mixed concrete" is a high cost share input item in the SJC project (estimated cost $2.3 million), it did not surface in the results of the analysis for the King County and rest of the state of Washington geographic regions. A special discussion of the upstream environmental factors associated with cement and ready mixed concrete is included in Section A4.5.4 of this report. Note here that they should be listed as a high environmental burden input items on two accounts – as a high building cost share input items and as a high EECR items.

Toxic releases to the environment have not been given an external environmental cost. Therefore, an EECR for input item toxic releases does not exist. For the SJC project, results are ranked on a building cost share basis only.

For toxic releases, the highest industry groups in King County and the rest of the state of Washington are listed in Tables A4.2.2 and A4.2.3 above. These two tables indicate many similarities between King County and the rest of the state of Washington for highest priority toxic release input items for the SJC project. The list of high priority items by building cost share includes the following industries:

- Wood products, primarily processed or finished (such as plywood, millwork, and cabinets),
- Steel mills and processed metal (primarily steel) products,
- Glass products,
- Adhesives and sealants,
- Refrigeration and heating equipment,
- Temperature controls,
- Elevators.

At this point in the SJC project analysis, the media of toxic releases – water, land, or air – was unknown. The input items are ranked above according to total toxic releases. Total toxic releases are broken down by media in the following "regional model" Baseline-

(continued)

Table A4.2.5

Inputs to Construction by Industry Classification	**EECR Cost per $**
Hardwood & softwood lumber, rough & dressed, exc. siding	0.18
Partitions and fixtures, except wood	0.17
Movable partitions except freestanding	0.16
Ceramic wall and floor tile	0.16
Wood poles, piles, & posts	0.15
Rough & dressed lumber, treated	0.13
Millwork	0.12
Wood kitchen cabinets	0.20
Structural wood products	0.18

NOTE: All data includes King County and the rest of the state of Washington. "Rest of U.S." data has been excluded.

Table A4.2.6: Summary List of Air Pollution Associated High Priority Inputs to Construction for the SJC Project Located in the State of Washington Ranked by Cost Share and EECR

Highest Air Pollution Burden Input Items Ranked by Building Cost Share (From Tables A4.2.2 and A4.2.3)

- Sawmills and planning mills
- Veneer and plywood
- Hardwood dimension and flooring
- Millwork
- Glass and glass products
- Wood preserving
- Asphalt felts and coatings
- Wood kitchen cabinets
- Wood products, nec
- Adhesives and sealants
- Metal partitions and fixtures
- Blast furnaces and steel mills
- Gypsum products
- Refrigeration and heating equipment

Highest Air Pollution Burden Input Items Ranked by EECR (≥ $0.25 per dollar of product cost)

- Cement
- Gypsum
- Structural steel
- Ready-mix concrete
- Brick
- Concrete block and brick
- Fabricated bar joists and concrete reinforcing bars
- Wallcoverings
- Other glass products including tempered, multiple glazed, & stained
- Interior and exterior architectural solvent and water type paints and coatings

Green™ analysis.

For greenhouse gas (CO_2) emissions associated with the SJC project, the list of highest environmental burden cost share input items is similar to toxic releases. Wood industry and metal industry input items dominate the lists for both King County and the rest of the state of Washington. Again, with the exception of sawmills and planing mills, the wood input items are primarily highly processed or finished products. In addition to wood and metal industries, glass products, adhesives and sealants, refrigeration and heating equipment, and asphalt felts and coatings industry groups appear on the list of greenhouse gases.

As mentioned above, cement and ready-mixed concrete did not appear as high cost share input items to the SJC project. However, both of these inputs, and especially cement production, are associated with high levels of greenhouse gas emissions. A discussion of upstream greenhouse gas emissions associated with the production of cement and ready mixed concrete is included in Section A4.5.4 of this report.

A4.3 BaselineGreen™ Analysis 3: Model of Environmental Burdens Associated with Regionally Based New Construction of Three Building Types

In the third analysis, a hypothetical input/output model assumed that all building materials and products were purchased locally and regionally for each of the three building types – residential, office, and commercial. Since BaselineGreen™ looks at the entire supply chain and is based in national industry averages, there are still impacts outside of the three county region in this hypothetical scenario.

Since the manufacture of any given material or product results in some negative environmental impacts, then all associated supply chain environmental burdens are local/regional in this model of upstream building activity.

A4.3.1 Upstream Environmental Burdens in King, Pierce, and Snohomish Counties

The major building-related upstream manufacturing industries contributing the highest share of toxic release burdens for each of the three building types in King, Pierce, and Snohomish Counties are listed in Tables A4.3.1.1, A4.3.1.2, and A4.3.1.3. These are cost share burdens, i.e., burdens associated with inputs that account for highest share of total construction cost of all inputs. (Note that total toxic releases have now been separated into three categories – toxic releases to water, land, and air.)

Cost share industry groups that consistently appear in the top of each list for King, Pierce, and Snohomish Counties are listed in Table A4.3.1.4. Industries listed in the first tier appear on the toxic release burden lists for all three building types. Industries listed in the second tier appear on the toxic release burden lists for office and commercial building types.

From Table A4.3.1.4 it is important to note that in King, Pierce, and Snohomish Counties, many kinds of wood product industries are associated with a bulk of toxic releases to air. For the first time, "nonwoven fabrics" appears as a high priority environmental burden industry group in the three county region. (Nonwoven fabrics are made of fibers bonded by mechanical, chemical, or thermal means. Geotextile cloth used for erosion control is an example.) Steel products, caulking compounds, ceramic tile, and brick also appear on the first tier list.

Refuse systems are establishments engaged in the collection and disposal of refuse by processing or incineration, waste treatment plants, landfills, and other disposal sites. Note that on the second tier list, several metal product industries appear, especially steel pro-

Table A4.3.1.1: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in King, Pierce, and Snohomish Counties Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Residential Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Structural shapes, sheet piling & concrete rein. bars	42%	Refuse systems	32%	Mineral wool	25%
Noncurrent-carrying devices	5%	Mineral wool	8%	Waferboard and oriented stand board	19%
Mineral wool	4%	Ready-mixed concrete	6%	Wood kitchen cabinets	11%
Nonwoven fabrics	4%	Waferboard and oriented stand board	5%	Brick & structural clay tile	8%
Waferboard and oriented stand board	4%	Caulking compounds & sealants	4%	Misc. wood products	5%
Ready-mixed concrete	3%	Structural shapes, sheet piling & concrete rein. bars	3%	Millwork	4%
Caulking compounds & sealants	2%	Nonwoven fabrics	2%	Hardboard products	4%
Rough & dressed lumber-treated, not edged	2%	Ceramic wall & floor tile	2%	Softwood plywood products: rough, sanded	2%
Steel nails, spikes, brads, and staples	2%	Rough & dressed lumber-treated, not edged	2%	Hardwood and softwood lumber, rough & dressed	2%
Hardwood and softwood lumber, rough & dressed	2%	Wood kitchen cabinets	2%		
		Builders' hardware	2%		

Table A4.3.1.2: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in King, Pierce, and Snohomish Counties Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Office Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Structural shapes, sheet piling & concrete rein. bars	12%	Refuse systems	37%	Wood kitchen cabinets	16%
Nonwoven fabrics	6%	Ready-mixed concrete	4%	Brick & structural clay tile	12%
Steel power boilers, except parts and attachments	5%	Caulking compounds & sealants	4%	Millwork	6%
Noncurrent-carrying devices	4%	Nonwoven fabrics	2%	Hardboard products	6%
Fabricated structural iron, steel and aluminum	3%	Ceramic wall & floor tile	2%	Fabricated structural iron, steel and aluminum	4%
Caulking compounds & sealants	3%	Unitary air conditioners	2%	Commercial and Industrial metal doors and frames	3%
Ready-mixed concrete	3%	Rough & dressed lumber-treated, not edged	2%	Hard surface floor coverings	3%
Metal tanks and vessels	3%	Builders' hardware	2%	Elevators and moving stairways	3%
Steel nails, spikes, brads, and staples	2%			Softwood plywood products: rough, sanded	2%
Rough & dressed lumber-treated, not edged	2%			Misc. wood products	2%
Fabricated plate work (boiler shops), nsk	2%			Hardwood and softwood lumber, rough & dressed	2%
Unitary air conditioners	2%			Hardwood flooring	2%
Custom roll form products	2%			Partitions and fixtures, except wood, nsk	2%
Ferrous pressure vessels and tanks	2%				
Hardwood and softwood lumber, rough & dressed	2%				
Ceramic wall & floor tile	2%				

Table A4.3.1.3: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in King, Pierce, and Snohomish Counties Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Commercial Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Steel power boilers, except parts and attachments	12%	Refuse systems	36%	Prefabricated metal building systems	15%
Prefabricated metal building systems	7%	Caulking compounds & sealants	4%	Brick & structural clay tile	9%
Nonwoven fabrics	6%	Nonwoven fabrics	2%	Millwork	7%
Structural shapes, sheet piling & concrete rein. bars	5%	Prefabricated metal building systems	2%	Hardboard products	7%
Noncurrent-carrying devices	5%	Asphalt felts & coatings nsk	2%	Wood partitions and fixtures, nsk	4%
Fabricated structural iron, steel and aluminum	3%	Ceramic wall & floor tile	2%	Fabricated structural iron, steel and aluminum	4%
Caulking compounds & sealants	3%	Rough & dressed lumber-treated, not edged	2%	Commercial and Industrial metal doors and frames	4%
Rough & dressed lumber-treated, not edged	3%	Unitary air conditioners	2%	Hardwood and softwood lumber, rough & dressed	3%
Hardwood and softwood lumber, rough & dressed	3%	Wood partitions and fixtures, nsk	2%	Softwood plywood products: rough, sanded	3%
Metal tanks and vessels	2%			Elevators and moving stairways	3%
Steel nails, spikes, brads, and staples	2%			Misc. wood products	2%
Fabricated plate work (boiler shops), nsk	2%			Rough & dressed lumber-treated, not edged	2%
All other current carrying wiring devices	2%			Sawmills and planing mills, nsk	2%
Custom roll form products	2%				
Ceramic wall & floor tile	2%				
Unitary air conditioners	2%				

Table A4.3.1.4: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in King, Pierce, and Snohomish Counties Contributing the Highest Share of Toxic Release Burdens Coimmon to Three Types of New Construction – Residential, Office, and Commercial (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water	Toxic Releases to Land	Toxic Releases to Air
1st Tier: All Three Building Types		
Nonwoven fabrics	Nonwoven fabrics	Hardwood and softwood lumber, rough & dressed
Rough & dressed lumber-treated, not edged	Rough & dressed lumber-treated, not edged	Softwood plywood products: rough, sanded
Hardwood and softwood lumber, rough & dressed	Caulking compounds & sealants	Hardboard products
Caulking compounds & sealants	Ceramic wall & floor tile	Miscellaneous wood products
Structural shapes, sheet piling & concrete reinforcing bars	Refuse systems	Wood partitions and fixtures, nsk
Steel nails, spikes, brads, and staples		Millwork
Noncurrent-carrying devices		Brick & structural clay tile
2nd Tier: Additional High Share Inputs for Office and Commercial Buildings		
Steel power boilers, except parts and attachments	Wood partitions and fixtures, nsk	Wood kitchen cabinets
Fabricated structural iron, steel and aluminum	Ready-mixed concrete	Elevators and moving stairways
Metal tanks and vessels	Builders' hardware	Fabricated structural iron, steel and aluminum
Fabricated plate work (boiler shops), nsk	Unitary air conditioners	
Custom roll form products		
Ready-mixed concrete		
Ceramic wall & floor tile		
3d Tier: Additional High Share Inputs for Residential Buildings		
Mineral wool	Mineral wool	Mineral wool
Waferboard and oriented strandboard	Waferboard and oriented strandboard	Waferboard and oriented strandboard
	Wood kitchen cabinets	Wood kitchen cabinets
	Structural shapes, sheet piling & concrete reinforcing bars	

ducts. Ready-mixed concrete, ceramic tile, builder's hardware, unitary air conditioners, elevators, and wood kitchen cabinets also appear. In the third tier list, mineral wool and waferboard / osb products appear.

A4.3.2 Upstream Environmental Burdens in the Rest of the State of Washington

Even though building materials and products are purchased locally or regionally, supply chain activities in the manufacturing sector of the economy extend beyond the political boundaries of the three county region. These supply chain industrial activities extend into the state of Washington and the rest of the U.S.

The major building-related upstream manufacturing industries contributing the highest share of toxic release burdens for each of the three building types in the rest of the state of Washington are listed in Tables A4.3.2.1, A4.3.2.2, and A4.3.2.3 below. These are cost share

Table A4.3.2.1: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in the Rest of the State of Washington Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Residential Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Vitreous plumbing fixtures	37%	Mineral wool	14%	Mineral wool	17%
Nonferrous wire and cable, including optical cable	23%	Ready-mixed concrete	13%	Ready-mixed concrete	15%
Plumbing fittings and brass goods	7%	Caulking compounds & sealants	9%	Caulking compounds & sealants	8%
Other vitreous plumbing fixtures	7%	Structural shapes, sheet piling & concrete rein. bars	5%	Vitreous plumbing fixtures	6%
Waferboard and oriented strandboard	5%	Vitreous plumbing fixtures	5%	Nonferrous wire and cable, including optical cable	6%
Nonwoven fabrics	5%	Waferboard and oriented strandboard	5%	Rough & dressed lumber-treated	3%
Other electronic equipment, nec (including automatic garage door openers)	2%	Rough & dressed lumber-treated	4%	Ceramic wall & floor tile	3%
Vacuum cleaner complete power units, central system type	2%	Ceramic wall & floor tile	3%	Plumbing fittings and brass goods	2%
Other insulated or covered wire and cable nec	2%	Nonferrous wire and cable, including optical cable	2%	Residential metal doors and frames	2%
Misc. wood products	2%	Paving mixtures & blocks	2%	Structural shapes, sheet piling & concrete rein. bars	2%
Hardboard products	2%	Wood preserving, nsk	2%	Softwood plywood products: rough, sanded	2%
		Noncurrent-carrying devices	2%		

Table A4.3.2.2: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in the Rest of Washington State Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Office Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Nonferrous wire and cable, including optical cable	70%	Nonferrous wire and cable, including optical cable	12%	Nonferrous wire and cable, including optical cable	22%
Plumbing fittings and brass goods	7%	Caulking compounds & sealants	11%	Ready-mixed concrete	9%
Alarm systems, including electric sirens and horns	6%	Ready-mixed concrete	10%	Caulking compounds & sealants	8%
Other insulated or covered wire and cable nec	4%	Rough & dressed lumber-treated, not edged	4%	Commercial and Industrial metal doors and frames	5%
Nonwoven fabrics	4%	Ceramic wall & floor tile	4%	Plumbing fittings and brass goods	3%
Intercommunication systems, incl inductive paging systems	2%	Wood poles, piles, and posts	2%	Rough & dressed lumber-treated, not edged	3%
Hardboard products	2%	Unitary air conditioners	2%	Ceramic wall & floor tile	3%
				Water proofing compounds	2%
				Boiler compounds	2%
				Residential metal doors and frames	2%
				Softwood plywood products: rough, sanded	2%

burdens, i.e., burdens associated with inputs that account for highest share of total construction cost of all inputs. (Note that total toxic releases have now been separated into three categories – toxic releases to water, land, and air.)

Cost share industry groups consistently in the top of each list for the rest of the state of Washington are listed in Table A4.3.2.4 below. Industries listed in the first tier are ones

Table A4.3.2.3: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in the Rest of Washington State Contributing the Highest Share (≥ 2%) of Toxic Release Burdens for New Commercial Construction (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water		Toxic Releases to Land		Toxic Releases to Air	
Nonferrous wire and cable, including optical cable	67%	Caulking compounds & sealants	11%	Nonferrous wire and cable, including optical cable	20%
Plumbing fittings and brass goods	7%	Nonferrous wire and cable, including optical cable	10%	Caulking compounds & sealants	8%
Electrical door openers, except garage door openers	4%	Rough & dressed lumber-treated	6%	Commercial and Industrial metal doors and frames	6%
Alarm systems, including electric sirens and horns	4%	Ceramic wall & floor tile	4%	Prefabricated metal building systems	4%
Other insulated or covered wire and cable nec	4%	Ready-mixed concrete	4%	Rough & dressed lumber-treated, not edged	4%
Nonwoven fabrics	4%	Asphalt felts & coatings nsk	3%	Ready-mixed concrete	4%
Hardboard products	2%	Wood partitions and fixtures, nsk	2%	Plumbing fittings and brass goods	3%
		Prefabricated metal building systems	2%	Ceramic wall & floor tile	3%
		Commercial and Industrial metal doors and frames	2%	Softwood plywood products: rough, sanded	2%
				Asphalt felts & coatings nsk	2%
				Residential metal doors and frames	2%
				Water proofing compounds	2%
				Boiler compounds	2%
				Concrete curing & floor hardening materials	2%

Table A4.3.2.4: Hypothetical Local/Regional Scenario: Building-Related Upstream Manufacturing Industries in the Rest of Washington State Contributing the Highest Share of Toxic Release Burdens Coimmon to Three Types of New Construction – Residential, Office, and Commercial (Note: "Rest of U.S." inputs omitted.)

Toxic Releases to Water	Toxic Releases to Land	Toxic Releases to Air
1st Tier: All Three Building Types		
Hardboard products	Rough & dressed lumber-treated, not edged	Rough & dressed lumber-treated, not edged
Plumbing fittings and brass goods	Caulking compounds & sealants	Softwood plywood products: rough, sanded
Nonferrous wire and cable, including optical cable	Ready-mixed concrete	Caulking compounds & sealants
Other insulated or covered wire and cable nec	Ceramic wall & floor tile	Ready-mixed concrete
Nonwoven fabrics	Nonferrous wire and cable, including optical cable	Ceramic wall & floor tile
		Nonferrous wire and cable, including optical cable
		Residential metal doors and frames
		Plumbing fittings and brass goods
2nd Tier: Additional High Share Items for Office and Commercial Buildings		
Alarm systems, including electric sirens and horns		Water proofing compounds
		Boiler compounds
		Concrete curing & floor hardening materials
3d Tier: Additional High Share Items for Residential Buildings		
Vitreous plumbing fixtures	Mineral wool	Mineral wool
Waferboard and oriented strandboard	Vitreous plumbing fixtures	Vitreous plumbing fixtures
Miscellaneous wood products	Structural shapes, sheet piling & concrete rein. bars	Structural shapes, sheet piling & concrete rein. bars
	Waferboard and oriented strandboard	
	Wood preserving, nsk	
	Paving mixtures & blocks	

that appear on the toxic release burden lists for all three building types. Industries listed in the second tier are ones that appear on the toxic release burden lists for two of the three building types.

In Table A4.3.2.4 note that in the rest of the state of Washington, wood product industries play a lesser role for all types of toxic releases. The input items nonwoven fabrics, nonferrous wire and cable, other wire and cable, plumbing fittings, and residential metal doors and frames all appear in the first tier list. Caulking compounds, ceramic tile, and ready-mixed concrete also appear on the list for all three building types.

A4.4 Summary of Three BaselineGreen™ Analyses

Tables A.4.4.1 through A4.4.5 below are comprehensive summaries of all the industry groups flagged by the three BaselineGreen™ analyses located anywhere in the state of Washington associated with the five environmental burden indicators discussed above: toxic releases to water, toxic releases to land, toxic releases to air, criteria air pollutants, and greenhouse gases. By comprehensive we mean that no industry has been omitted from a list simply because its share of a particular environmental burden may be less than that of other industries. Even a small toxic spill into a sensitive salmon habitat can have a major impact. Once again, it is important to note that the data in the following tables is based on a baseline derived from national averages.

Each table sorts the input industries by SIC code and has a three-tier format. The first tier lists flagged industries with inputs to all three building types. The second tier lists flagged industries that typically have inputs to office and commercial buildings. The third tier lists flagged industries common to residential buildings.

Tables A4.4.1 through A4.4.5 will be used to guide the investigation into toxic release inventory, air pollution, and greenhouse gas data in the remainder of this report. For example, Table A4.4.1 indicates that the industry group "nonwoven fabrics" is associated with toxic releases to water for all building types. The SIC code for this industry is 2297 under the major SIC code of 22. State of Washington and U.S. EPA records for toxic release inventory reports will be examined to determine if such an industrial facility or facilities exist in the three county region and the rest of the state of Washington. If such a facility can be identified and located, then its toxic release report will be reviewed and compared to a benchmark – the average toxic releases to water for all similar industrial facilities in the U.S.

If green building practices include specifying local and regional materials, then this process attempts to make certain that local and regional manufacturers and suppliers of building materials and products are not associated with negative upstream environmental factors affecting salmon habitat. It is a first step in identifying local and regional "salmon-friendly" building materials and products.

This section of the report presents the findings of the three BaselineGreen™ analyses simply as the comprehensive summary lists presented in the five tables below. A detailed discussion of toxic release, air pollution, and greenhouse gas data for local, regional, and statewide building related industries and identification and location of these industries is included in sections 4.5 and 4.6 below.

Table A4.4.1: Comprehensive List of Industries in the State of Washington Associated with Upstream Toxic Releases to Water Identified by BaselineGreen™ Sorted by SIC Code (Based on National Industry Averages)

SIC Code Major Group	SIC Code Industry Number	Industry Group
1st Tier: Inputs to All Three Building Types		
01 Agriculture	0139	Hay
22 Textiles	2297	Nonwoven fabrics
24 Lumber and Wood Products	2421 and 2426	Hardwood and softwood lumber, rough & dressed Hardwood and softwood lumber
	2431	Millwork
	2436	Softwood plywood products
	2491	Rough & dressed lumber-treated, not edged
	2493	Hardboard products
28 Chemicals	2851	Solvent and water type paints
	2891	Caulking compounds & sealants
33 Primary Metal	3312	Structural shapes, sheet piling & concrete reinforcing bars
	3315	Steel nails, spikes, brads, and staples
	3356 and 3357	Nonferrous wire and cable, including optical cable Other insulated or covered wire and cable nec
34 Fabricated Metal	3432	Plumbing fittings and brass goods
	3449	Structural shapes, sheet piling & concrete reinforcing bars
36 Electrical Equipment	3644	Noncurrent-carrying devices
2nd Tier: Additional Inputs for Office and Commercial Buildings		
32 Stone, Clay, Glass, and Concrete	3253	Ceramic wall & floor tile
	3273	Ready-mixed concrete
34 Fabricated Metal	3441	Fabricated structural iron, steel and aluminum
	3443	Fabricated plate work (boiler shops), nsk
	3443	Steel power boilers, except parts and attachments
	3443	Metal tanks and vessels
	3449	Custom roll form products
36 Electrical Equipment	3679	Alarm systems, including electric sirens and horns
3d Tier: Additional Inputs for Residential Buildings		
24 Lumber and Wood Products	2493	Waferboard and oriented strandboard
	2499	Miscellaneous wood products
32 Stone, Clay, Glass, and Concrete	3261	Vitreous china plumbing fixtures
	3296	Mineral wool

Table A4.4.2: Comprehensive List of Industries in the State of Washington Associated with Upstream Toxic Releases to Land Identified by BaselineGreen™ Sorted by SIC Code (Based on National Industry Averages)

SIC Code Major Group	SIC Code Industry Number	Industry Group
1st Tier: Inputs to All Three Building Types		
22 Textiles	2297	Nonwoven fabrics
24 Lumber and Wood Products	2491	Rough & dressed lumber-treated, not edged
28 Chemicals	2891	Caulking compounds & sealants
32 Stone, Clay, Glass, and Concrete	3253	Ceramic wall & floor tile
	3273	Ready-mixed concrete
49 Electric, Gas, and Sanitary Services	4923	Refuse systems
2nd Tier: Additional Inputs to Office and Commercial Buildings		
34 Fabricated Metal	3429	Builders' hardware
35 Industrial & Commercial Machinery	3585	Unitary air conditioners
3d Tier: Additional Inputs to Residential Buildings		
24 Lumber and Wood Products	2431	Wood kitchen cabinets
	2491	Wood preserving
	2493	Waferboard and oriented strandboard
32 Stone, Clay, Glass, and Concrete	3261	Vitreous china plumbing fixtures
	3296	Mineral wool
33 Primary Metal	3312	Structural shapes, sheet piling & concrete reinforcing bars

Table A4.4.3: Comprehensive List of Industries in the State of Washington Associated with Upstream Toxic Releases to Air Identified by BaselineGreen™ Sorted by SIC Code (Based on National Industry Averages)

SIC Code Major Group	SIC Code Industry Number	Industry Group
1st Tier: Inputs to All Three Building Types		
24 Lumber and Wood Products	2421 and 2426	Hardwood and softwood lumber, rough & dressed Hardwood and softwood lumber Hardwood dimension and flooring
	2431	Millwork
	2431	Wood kitchen cabinets
	2431	Wood partitions and fixtures, nsk
	2436	Softwood plywood products
	2436	Veneer and plywood
	2491	Rough & dressed lumber-treated, not edged
	2491	Wood preserving
	2493	Hardboard products
	2499	Miscellaneous wood products
28 Chemicals	2851	Solvent and water type paints
	2891	Caulking compounds & sealants
32 Stone, Clay, Glass, and Concrete	3253	Ceramic wall & floor tile
	3273	Ready-mixed concrete
	3297	Brick & structural clay tile
33 Primary Metal	3312	Structural shapes, sheet piling & concrete reinforcing bars
	3315	Steel nails, spikes, brads, and staples
	3356 and 3357	Nonferrous wire and cable, including optical cable
		Other insulated or covered wire and cable nec
34 Fabricated Metal	3432	Plumbing fittings and brass goods
	3449	Structural shapes, sheet piling & concrete reinforcing bars
36 Electrical Equipment	3644	Noncurrent-carrying devices
2nd Tier: Additional Inputs to Office and Commercial Buildings		
25 Furniture and Fixtures	2541	Wood partitions and fixtures
	2542	Metal partitions and fixtures
28 Chemicals and Allied Products	2899	Waterproofing compounds
	2899	Boiler compounds
	2899	Concrete curing and floor hardening compounds
30 Rubber and Misc. Plastics Products	3089	Hard surface floor coverings
32 Stone, Clay, Glass, and Concrete	3211 and 3231	Glass and glass products
34 Fabricated Metal	3441	Fabricated structural iron, steel and aluminum
	3442	Commercial and industrial metal doors and frames
	3443	Fabricated plate work (boiler shops), nsk
	3443	Steel power boilers, except parts and attachments
	3443	Metal tanks and vessels
	3449	Custom roll form products
35 Industrial and Commercial Equip.	3534	Elevators and moving stairways
36 Electrical Equipment	3679	Alarm systems, including electric sirens and horns

(continued)

Table A4.4.3

SIC Code Major Group	SIC Code Industry Number	Industry Group
3d Tier: Additional Inputs to Residential Buildings		
24 Lumber and Wood Products	2493	Waferboard and oriented strandboard
	2499	Miscellaneous wood products
30 Rubber and Misc. Plastics Products	3088	Plastic plumbing fixtures
	3089	Building plastics products
32 Stone, Clay, Glass, and Concrete	3261	Vitreous china plumbing fixtures
	3296	Mineral wool
34 Fabricated Metal	3442	Residential metal doors and frames

Table A4.4.4: Comprehensive List of Industries in the State of Washington Associated with Upstream Criteria Air Pollutant Releases Identified by BaselineGreen™ Sorted by SIC Code (Based on National Industry Averages)

SIC Code Major Group	SIC Code Industry Number	Industry Group
1st Tier: Inputs to All Three Building Types		
24 Lumber and Wood Products	2421 and 2426	Hardwood and softwood lumber, rough & dressed Hardwood and softwood lumber Hardwood dimension and flooring
	2431	Millwork
	2431	Wood kitchen cabinets
	2436	Softwood plywood products
	2436	Veneer and plywood
	2491	Wood preserving
	2499	Miscellaneous wood products
28 Chemicals	2851	Solvent and water type paints
32 Stone, Clay, Glass, and Concrete	3241	Cement
	3273	Ready-mixed concrete
	3275	Gypsum building products
33 Primary Metal	3312	Structural shapes, sheet piling & concrete reinforcing bars
	3356 and 3357	Nonferrous wire and cable, including optical cable Other insulated or covered wire and cable nec
34 Fabricated Metal	3441 and 3449	Structural shapes, sheet piling & concrete reinforcing bars
2nd Tier: Additional Inputs to Office and Commercial Buildings		
24 Lumber and Wood Products	2421	Sawmills and planning mills
	2491	Wood preserving
25 Furniture and Fixtures	2542	Metal partitions and fixtures
28 Chemicals and Allied Products	2891	Adhesives and sealants
29 Petroleum Refining & Related Industries	2951	Asphalt felts and coatings
30 Rubber and Misc. Plastics Products	3069	Wallcoverings
	3089	Hard surface floor coverings
32 Stone, Clay, Glass, and Concrete	3211 and 3231	Glass and glass products
	3251	Brick and structural clay tile
33 Primary Metal	3312	Blast furnaces and steel mills
34 Fabricated Metal	3441	Fabricated structural iron, steel and aluminum
	3442	Commercial and industrial metal doors and frames
	3443	Steel power boilers, except parts and attachments
	3444	Sheet metal work
	3449	Custom roll form products
35 Industrial and Commercial Equip.	3534	Elevators and moving stairways
	3585	Refrigeration and heating equipment
3rd Tier: Additional Inputs to Residential Buildings		
14 Mining and Quarrying Nonmetallic Minerals	1429	Crushed and broken stone
24 Lumber and Wood Products	2493	Waferboard and oriented strandboard
30 Rubber and Misc. Plastics Products	3089	Building plastics products
32 Stone, Clay, Glass, and Concrete	3251, 3271	Paving mixtures and blocks
	3271	Concrete block and brick
	3296	Mineral wool

Table A4.4.5: Comprehensive List of Industries in the State of Washington Associated with Upstream Greenhouse Gas Emissions Identified by BaselineGreen™ Sorted by SIC Code (Based on National Industry Averages)

SIC Code Major Group	SIC Code Industry Number	Industry Group
1st Tier: Inputs to All Three Building Types		
24 Lumber and Wood Products	2431	Millwork
28 Chemicals	2851	Solvent and water type paints
32 Stone, Clay, Glass, and Concrete	3241	Cement
	3273	Ready-mixed concrete
34 Fabricated Metal	3441	Fabricated structural iron, steel and aluminum
2nd Tier: Additional Inputs to Office and Commercial Buildings		
24 Lumber and Wood Products	2421	Sawmills and planning mills
	2421 and 2426	Hardwood dimension and flooring
	2431	Wood kitchen cabinets
	2439	Structural wood members
	2436	Veneer and plywood
	2491	Wood preserving
	2493	Reconstituted wood products
25 Furniture and Fixtures	2542	Metal partitions and fixtures
28 Chemicals and Allied Products	2891	Adhesives and sealants
29 Petroleum Refining & Related Industries	2951	Asphalt felts and coatings
32 Stone, Clay, Glass, and Concrete	3211 and 3231	Glass and glass products
	3275	Gypsum building products
33 Primary Metal	3312	Blast furnaces and steel mills
34 Fabricated Metal	3441	Fabricated structural metal
	3442	Commercial and industrial metal doors and frames
	3443	Steel power boilers, except parts and attachments
	3444	Sheet metal work
	3448	Prefabricated metal buildings
	3449	Custom roll form products
	3498	Pipes' valves, pipe fittings
	3499	Fabricated metal products, nec
35 Industrial and Commercial Equip.	3534	Elevators and moving stairways
	3585	Refrigeration and heating equipment
3rd Tier: Additional Inputs to Residential Buildings		
14 Mining and Quarrying Nonmetallic Minerals	1429	Crushed and broken stone
	1442	Construction sand and gravel
24 Lumber and Wood Products	2421	Hardwood and softwood lumber
	2431	Wood kitchen cabinets
	2493	Waferboard and oriented strandboard
30 Rubber and Misc. Plastics Products	3089	Building plastics products
32 Stone, Clay, Glass, and Concrete	3251, 3271	Paving mixtures and blocks
	3271	Concrete block and brick
	3296	Mineral wool
34 Fabricated Metal Products	3441 and 3449	Structural shapes, sheet piling & concrete reinforcing bars

A4.5 Toxic Release Inventory, Air Pollution, and Greenhouse Gas Emissions Gas Emissions Data for Industrial Facilities

Following BaselineGreen™, a review of toxic release inventory, criteria air pollutants, and greenhouse gas emissions reports for the state of Washington was undertaken to identify point source industries for these upstream environmental burdens. The industry groups and/or facilities investigated were the high priority industry groups identified in Tables A4.4.1 through A4.4.5 in Section A4.4 above.

This review of toxic release inventory (TRI) data attempts to include all industrial facilities in the State of Washington. However, the TRI data used for BaselineGreen™ relies on reports submitted by the industries themselves. It is possible that some releases may be un- or under-reported and that some TRI reports contain errors or may have missing information.

A4.5.1 Toxic Releases to Water

Table A4.5.1.1 below lists the industry groups that were identified in the BaselineGreen™ analysis as sources of toxic releases to water in the King, Pierce, and Snohomish (KPS) three county region and in the rest of the state of Washington. The industry groups listed in this table were the ones that were selected for further investigation because they are the "first tier" items, i.e., upstream industrial inputs to all three building types. This detailed investigation included a review of TRI reports and, in some cases, calls to facility personnel to verify information.

The investigation of 1999 TRI reports for all industrial facilities in the state of Washington revealed 70 pounds of direct upstream burdens associated with toxic releases to water for the building related industry groups or facilities listed above. All of this burden came from three facilities manufacturing treated lumber (SIC 2491) as shown in Table A4.5.1.2 below. Creosotes used for treating lumber are derived from coal tar; they are known skin irritants and are indicated to be probably carcinogenic to humans by the International Agency for Research on Cancer. Arsenic is a known human carcinogen, and copper is not known to cause cancer. Rather than conduct a detailed investigation of the effects of these releases on salmon, the authors recommend application of the precautionary principle; if these chemicals are harmful to humans, they are most likely harmful to salmon as well.

To put building related industries in perspective with all other industries, it is worthwhile to examine the toxic releases to water of the paper industry. A single paper pulp plant located in western Washington releases more than 500,000 pounds of toxic releases to

Table A4.5.1.1: Industry Groups in KPS Counties and the State of Washington Identified as Possible Sources of Toxic Releases to Water Sorted bySIC Code

Industrial Facilities in KPS Counties	SIC Code	Industrial Facilities in the Rest of the State of Washington	SIC Code
Nonwoven fabrics	2297	Nonwoven fabrics	2297
Hardwood and softwood lumber, rough & dressed	2421 & 2426	Millwork	2431
Rough & dressed lumber-treated, not edged	2491	Softwood plywood products	2436
Caulking compounds & sealants	2891	Hardboard products	2493
Structural shapes, sheet piling & concrete reinforcing bars	3312 & 3449	Solvent and water type paints	2851
Steel nails, spikes, brads, and staples	3315	Nonferrous wire and cable, including optical cable	3356 & 3357
Noncurrent-carrying devices	3644	Other insulated or covered wire and cable nec	3356 & 3357
		Plumbing fittings and brass goods	3432

water each year. There are 10 other such facilities in the Puget Sound region with reported annual toxic releases to water ranging from 14,000 to 530,000 pounds each. The total toxic releases to water in 1999 from all 10 facilities were almost 2.5 million pounds.

One manufacturer of fabrics was found in Pierce County. It is listed under SIC code 2295 which is a manufacturer of coated textiles. Since the SIC code is not 2297, no follow-up investigation was undertaken to determine whether or not this facility is producing building-related products. However, the TRI reports show that this facility reported zero toxic releases to water in 1999. (TRI reported indicated toxic releases to air and off-site transfers.)

No toxic releases to water from millwork (SIC 2431) or wood product (e.g., plywood, SIC 2436) facilities were documented. Some industrial facilities listed as manufacturing wood products report toxic releases to water but these are from combined wood and paper manufacturing operations. Almost all the toxic releases to water are from the paper manufacturing division of the facility. (This fact has been verified by phone conversations with personnel from one of the facilities.)

No manufacturers of paints (SIC 2851) or caulking compounds (SIC 2891) with reported toxic releases to water were found in the entire state of Washington.

For steel mills (SIC 3312 and 3449), the largest facility in the region transfers its solid waste toxic inventory of various metal compounds out of state. The total transfer is about 4.7 million pounds in 1999. A small steel foundry in Pierce County had toxic inventory of various metal compounds of about 500 pounds in 1999. However, follow-up investigation revealed that this facility does not manufacture products for the buildings.

One manufacturer of metal tube and wire products (SIC 3356 and 3357) was found in the state of Washington. Further inquiry revealed that it does not produce building related products.

No manufacturers of electric equipment (SIC 3644) with reported toxic releases to water were found in the entire state of Washington.

In general, compared to other industries such as paper manufacturing, building related industrial toxic releases to water in 1999 were negligible. This is true for both the three county region and the rest of the State of Washington.

Table A4.5.1.1: Industry Groups in KPS Counties and the State of Washington Identified as Possible Sources of Toxic Releases to Water Sorted bySIC Code

Facility	County	Emission	Amount (lbs)
Cascade Pole and Lumber	Pierce	Creosotes	10
Allweather Wood Treaters	Clark	Chromium Compounds	12
		Arsenic	10
		Copper	7
Exterior Wood, Inc	Clark	Chromium Compounds	12
		Arsenic	12
		Copper Compounds	7

A4.5.2 Toxic Releases to Land/Underground

Table A4.5.2 below lists the industry groups that were identified in the BaselineGreen™ analysis as sources of toxic releases to land/underground in the King, Pierce, and Snohomish (KPS) three county region and in the rest of the state of Washington. As with the industry groups identified as sources of toxic releases to water, the industry groups listed in this table were the ones that were selected for further investigation because they are the "first tier" items, i.e., upstream industrial inputs to all three building types. This detailed investigation included a review of TRI reports and, in some cases, calls to facility personnel to verify information.

The investigation revealed no direct upstream burdens associated with toxic releases to land for the building related industry groups listed above.

No manufacturers of nonwoven fabrics with reported toxic releases to land were found in the entire state of Washington.

Three facilities manufacturing treated lumber were found in the KPS three county region. None reported any toxic releases to land.

No manufacturers of caulking compounds with reported toxic releases to land were found in the entire state of Washington.

No manufacturers of ceramic tile with reported toxic releases to land were found in the entire state of Washington.

One manufacturer of wire products was found in the state of Washington. It is unclear whether or not it is a building product. However, zero toxic releases to land were reported in 1999.

Refuse systems consistently appear as a high priority item in the KPS three county region. Refuse systems are defined in the SIC index as primarily solid waste disposal in landfills, hazardous waste disposal, and incineration operations. Note that this is upstream, or supply chain, solid waste disposal, not construction solid waste or building post-use (demolition) solid waste. This is an indication that the solid waste generated by the upstream manufacturing of building materials and products is a high priority concern relative to toxic releases to land.

In general, with the exception of refuse, building related industrial toxic releases to land in 1999 were zero. This is true for both the three county region and the rest of the State of Washington.

Table A4.5.2: Industry Groups in KPS Counties and the State of Washington Identified as Possible Sources of Toxic Releases to Land Sorted by SIC Code

Industrial Facilities in KPS Counties	SIC Code	Industrial Facilities in the Rest in the Rest of the State of Washington	SIC Code
Nonwoven fabrics	2297	Nonwoven fabrics	2297
Rough & dressed lumber-treated, not edged	2491	Rough & dressed lumber-treated, not edged	2491
Caulking compounds & sealants	2891	Caulking compounds & sealants	2891
Ceramic wall & floor tile	3253	Ceramic wall & floor tile	3253
Ready-mixed concrete	3273	Ready-mixed concrete	3273
Refuse systems	4923	Nonferrous wire and cable, including optical cable	3356 & 3357

A4.5.3 Toxic Releases to Air

Table A4.5.3 below lists the industry groups that were identified in the BaselineGreen™ analysis as sources of toxic releases to air in the King, Pierce, and Snohomish (KPS) three county region and in the rest of the state of Washington. As with the industry groups identified as sources of toxic releases to water, the industry groups listed in this table were the ones that were singled out for further investigation because they are the "first tier" items, i.e., upstream industrial inputs to all three building types. This detailed investigation included a review of TRI reports and, in some cases, calls to facility personnel to verify information.

Toxic releases to air from building related wood product industries (SIC codes 2421, 2426, 2431, and 2436) located in the KPS three county region appear to be quite substantial. One millwork facility in King County reported 359,000 pounds of toxic releases to air in 1999 (the highest amount for all reporting facilities in King County). Six other wood product facilities in the three county region reported toxic releases to air totaling more than 137,000 pounds in 1999. In the rest of the state of Washington, reported toxic releases to air from building related wood product industries totaled more than 108,000 pounds in 1999.

Again, to put building related industries in perspective with all other industries, it is worthwhile to examine the toxic releases to air of the paper industry. A single paper pulp plant located in western Washington releases more than 2.5 million pounds of toxic releases to air each year. There are 10 other such facilities in the Puget Sound region with reported annual toxic releases to air ranging from 32,000 to over 1.4 million pounds each. The total toxic releases to air in 1999 from all 10 facilities were almost 7.5 million pounds. As a percentage of the paper industry, building related wood product industries accounted for about 8% of toxic releases to air in 1999.

Total toxic releases to air for the top one hundred reporting industrial facilities in the entire state of Washington were almost 19.8 million pounds in 1999. As a percentage of total statewide toxic releases to air, building related wood product industries accounted for only 3% of the total in 1999.

Eight manufacturers of paints (SIC 2851) located in the three county region reported toxic

Table A4.5.3: Industry Groups in KPS Counties and the State of Washington Identified as Possible Sources of Toxic Releases to Air Sorted by SIC Code

Industrial Facilities in KPS Counties	SIC Code	Industrial Facilities in the Rest of the State of Washington	SIC Code
Hardwood and softwood lumber, rough & dressed	2421 & 2426	Hardwood and softwood lumber, rough & dressed	2421 & 2426
Millwork	2431	Millwork	2431
Wood kitchen cabinets	2431	Wood kitchen cabinets	2431
Wood partitions and fixtures, nsk	2431	Veneer and plywood	2436
Softwood plywood products	2436	Softwood plywood products	2436
Hardboard products	2493	Rough & dressed lumber-treated	2491
Miscellaneous wood products	2499	Wood preserving	2491
Solvent and water type paints	2851	Solvent and water type paints	2851
Ready-mixed concrete	3273	Caulking compounds & sealants	2891
Brick & structural clay tile	3297	Ceramic wall & floor tile	3253
		Ready-mixed concrete	3273
		Brick & structural clay tile	3297
		Nonferrous wire and cable, including optical cable	3356 & 3357
		Residential metal doors and frames	3442
		Plumbing fittings and brass goods	3432

releases to air of about 97,000 pounds in 1999. As a percentage of total statewide toxic releases to air, paint industries accounted for less than 0.5% of the total in 1999.

No manufacturers of caulking compounds, adhesives, and sealants (SIC code 2891) with reported toxic releases to air were found in the entire state of Washington.

Toxic releases to air associated with the manufacture of ready-mixed concrete (SIC code 3273) are discussed in detail in Section A4.5.4 of this report.

Two brick manufacturing facilities (SIC code 3251) were identified in the state of Washington. One in the KPS three county region reported toxic air releases of over 52,000 pounds in 1999, down from over 67,000 pounds in 1996. (The sole toxic air release reported was hydrofluoric acid.) The one additional brick plant located in the rest of the state of Washington reported toxic releases to air of over 42,000 pounds in 1999. The combined total of 94,000 pounds is less than 0.5% of the statewide total.

No manufacturers of ceramic tile (SIC code 3253) with reported toxic releases to air were found in the entire state of Washington.

One manufacturer of metal tube and wire products was found in the state of Washington. Further inquiry revealed that it does not produce building related products.

Primary metal industries (SIC major group 33) account for almost all toxic releases to air in the state of Washington (especially aluminum industries). It is unclear, however, which of the facilities that report toxic releases to air actually manufacture building related products. Many aluminum manufacturing facilities, for example, produce parts and components for the aircraft industry. Further follow-up investigation is needed to determine which facilities are making building related products.

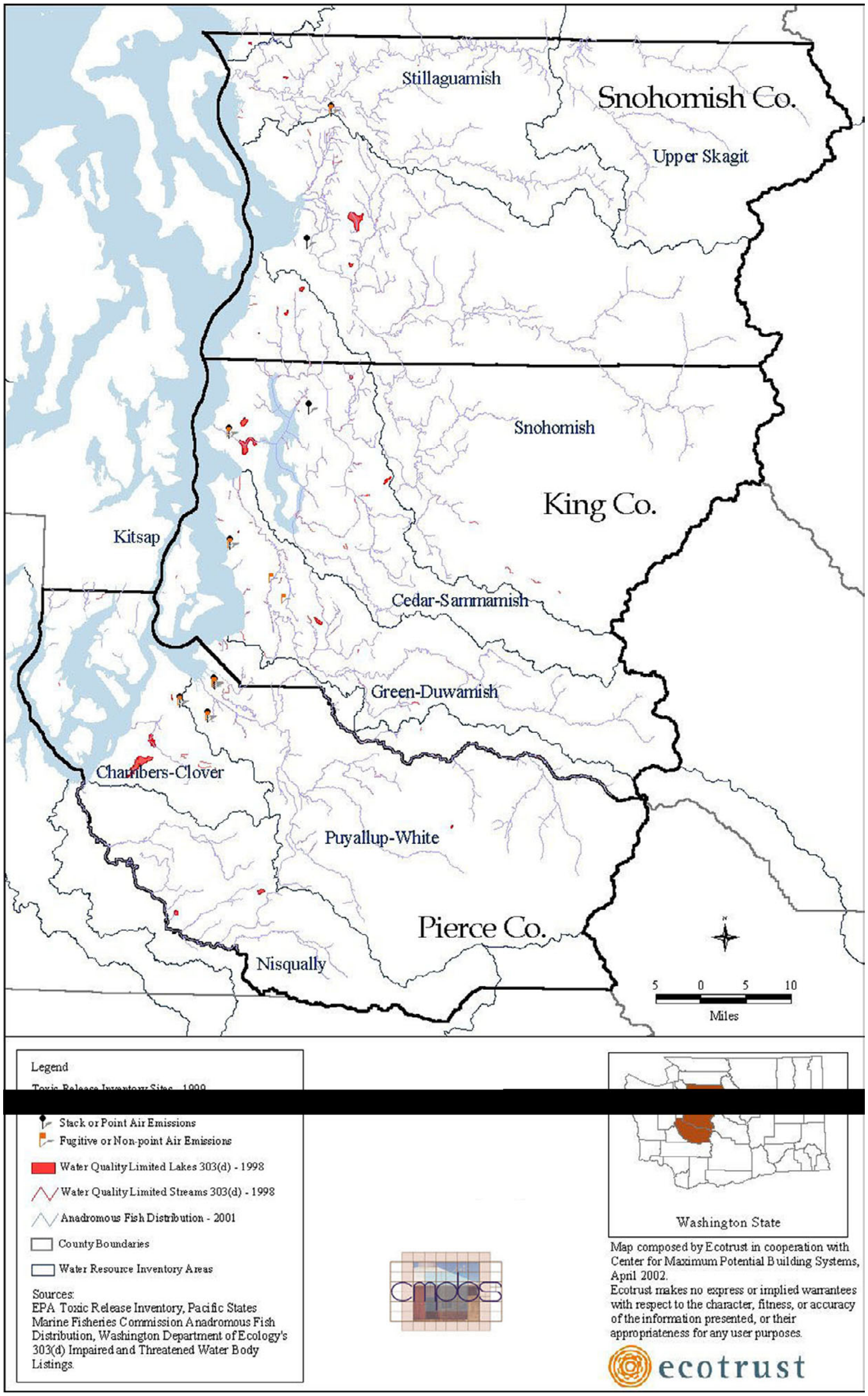
One pipe and pipe fittings manufacturing facility (SIC code 3432) was identified in the KPS three county region. It is located in King County and reported toxic air releases of over 49,000 pounds in 1999.

No manufacturers of residential metal doors and frames (SIC code 3442) with reported toxic releases to air were found in the entire state of Washington.

Several other facilities manufacturing fabricated metal products (SIC major group 34) are located in the three county region and in the rest of the state of Washington. Similar to primary metal industries, it is uncertain how many of these facilities manufacture building related products. Further follow-up investigation (e.g., calls to each individual facility) is needed and was not undertaken for this report. This would be an important step to take in an analysis of office and commercial buildings (see 2nd tier of Table A4.4.3).

Although not included in the table above, the facility with the highest level of toxic releases to air reported in 1999 was one that manufactured mineral wool products (SIC code 2297). This industry group has been identified as a high priority item for residential buildings 3rd tier, Table A4.4.3). The facility, which is located in the three county region, reported over 71,000 pounds of toxic releases to air in 1999.

Figure A4.5.3: Building Related Industries with Toxic Releases to Air in the Tri-County Region



In general, compared to other industries, building related industrial toxic releases to air in 1999 were small. Including the mineral wool manufacturing facility mentioned above, the percentage of total statewide toxic releases to air that can be attributed to building related industries is less than 5% of the total.

Building related toxic release inventory sites in the three county region reporting discharges to air are shown in Figure A4.5.3.

A4.5.4 Air Pollution

Table A4.5.4 below lists the industry groups that were identified in the BaselineGreen™ analysis as sources of air pollution in the King, Pierce, and Snohomish (KPS) three county region and in the rest of the state of Washington. As with the industry groups identified as sources of toxic releases, the industry groups listed in this table were the ones that were selected for further investigation because they are the "first tier" items, i.e., upstream industrial inputs to all three building types. This detailed investigation included a review of criteria air pollutant reports and, in some cases, calls to facility personnel to verify information.

The major air pollutant associated with wood product industries (SIC codes 2421, 2426, 2431, 2436, and 2499) is typically VOC emissions. VOC emissions from wood product industries located in the KPS three county region appear to be minor. One millwork facility in the three county region reported 158 tons of VOC emissions in 1999. Compared to almost 950 tons of VOC emissions from one paper mill, this amount seems relatively small.

In the rest of the state of Washington, VOC emissions from 19 wood product industries and one steel product facility totaled about 965 tons in 1999. VOC emissions for the top twenty-five reporting industrial facilities in the entire state of Washington were more than 11,250 tons in 1999. As a percentage of total statewide VOC emissions, building related wood product industries accounted for only 9% of the total in 1999.

One sawmill facility in King County reported 10 tons of sulphur dioxide emissions in 1999. Compared to over 550 tons from a cement plant (see below) and almost 88,000 tons from a power plant, this amount seems negligible.

Table A4.5.4: Industry Groups in KPS Counties and the State of Washington Identified as Sources of Criteria Air Pollutants Sorted by SIC Code

Industrial Facilities in KPS Counties	SIC Code	Industrial Facilities in the Rest of the State of Washington	SIC Code
Sawmills and planning mills	2421	Sawmills and planning mills	2421
Hardwood, dimension and flooring	2421 & 2426	Hardwood, dimension and flooring	2421 & 2426
Millwork	2431	Millwork	2431
Wood kitchen cabinets	2431	Wood kitchen cabinets	2431
Veneer and plywood	2436	Veneer and plywood	2436
Wood products, nec	2499	Softwood plywood	2436
Adhesives and sealants	2891	Wood preserving	2491
Glass and glass products	3211 & 3231	Wood products, nec	2499
Cement, hydraulic	3241	Solvent and water type paints	2851
Ready-mixed concrete	3273	Cement, hydraulic	3241
Gypsum building materials	3275	Ready-mixed concrete	3273
Structural shapes, sheet piling, concrete reinforcing bars	3312, 3341	Gypsum building materials	3275
		Nonferrous wire and cable, including optical cable	3356 & 3357

No manufacturers of adhesives and sealants (SIC code 2891) with reported air pollutant emissions were found in the entire state of Washington.

Emissions associated with the manufacture of cement (SIC code 3241) account for a substantial portion of air pollutant emissions in the KPS three county region but only a small portion of air pollutants in the rest of the state of Washington. Two cement plants and one lime facility in the KPS three county region account for the following emissions in the region:

- 29% of PM-10
- 19% of PM-2.5
- 13% of carbon monoxide
- 45% nitrogen oxide
- 23% sulphur dioxide.

One brick manufacturing facility (SIC code 3251) was identified in the KPS three county region. It is located in King County and reported relatively small amounts of air pollutant releases in 1999.

No manufacturers of glass building products (SIC codes 3211 and 3231) with reported air pollution releases were found in the entire state of Washington. (There are some glass container manufacturers, however.)

One gypsum manufacturing facility (SIC code 3275) was identified in the KPS three county region. It is located in Pierce County and reported relatively small amounts of air pollutant releases in 1999.

One steel manufacturing facility (SIC code 33) was identified in the KPS three county region. It is located in King County and reported moderate amounts of air pollutant releases in 1999.

In general, with one exception, building related industrial air pollutant releases in 1999 were small. That exception is the cement industry which accounts for a fairly large share of all types of criteria air pollutant emissions in the three county region.

A4.5.5 Greenhouse Gases

Table A4.5.5 below lists the industry groups that were identified in the BaselineGreen™ analysis as sources of greenhouse gases in the King, Pierce, and Snohomish (KPS) three county region and in the rest of the state of Washington. As with the industry groups identified as sources of toxic releases, the industry groups listed in this table were the ones that were selected for further investigation because they are the "first tier" items, i.e., upstream industrial inputs to all three building types.

Table A4.5.5: Industry Groups in KPS Counties and the State of Washington Identified as Sources of Greenhouse Gases Sorted by SIC Code

Industrial Facilities in KPS Counties	SIC Code	Industrial Facilities in the Rest of the State of Washington	SIC Code
Millwork	2431	Millwork	2431
Cement, hydraulic	3241	Solvent and water type paints	2851
Ready-mixed concrete	3273	Cement, hydraulic	3241
Fabricated structural iron, steel and aluminum	3441	Ready-mixed concrete	3273
		Fabricated structural metal	3441

Greenhouse gas emissions are not required to be reported to state or U.S. regulatory agencies. They can be estimated for a given year, however, if both annual energy consumption and type of fuel used are known for a particular manufacturing facility. In some cases, annual product output by weight can also be an indicator of greenhouse gas emissions.

Greenhouse gas emissions for millwork facilities (SIC code 2431) and paint manufacturers (SIC code 2851) could not be verified. Information regarding both annual production output and annual energy use could not be obtained within the timetable allowed for this report. Further investigation of each millwork and paint manufacturing facility in the three county region and the rest of the state of Washington would have to be undertaken to estimate total greenhouse gas emissions for these two industry groups.

Emissions of CO2 associated with the manufacture of cement (SIC code 3241) account for a substantial portion of greenhouse gas emissions in the KPS three county region and possibly a large portion of GHGs in the rest of the state of Washington. Two cement plants in the KPS three county region account for approximately 1 million tons of CO2 emissions per year. This is the combined total for fossil fuel energy generated electricity use, on site fuel combustion, and chemical reactions in processing lime. The two cement manufacturing facilities are presently the 5th and 6th largest users of electricity provided by Seattle City Light.

By comparison, emissions of CO2 associated with the manufacture of fabricated steel products (SIC code 3441) accounts for a smaller portion of greenhouse gas emissions in the KPS three county region. The CO2 emission total for the one steel product manufacturer in the region is approximately 53,000 tons per year. This is the total for fossil fuel energy generated electric power. This steel manufacturing facility is the largest user of electricity provided by Seattle City Light.

A4.6 Discrepancies Between BaselineGreen™ Findings and Review of Toxic Release Inventory Data for Industrial Facilities

The BaselineGreen™ approach to regional economic modeling-based Life Cycle Assessment (LCA) follows standard practice in both LCA and economic input/output modeling, which is to model each unit process and/or sector using data reflecting the average process or factory in that process class or sector. Thus, in LCA, unit process data for coal-fired boilers will generally reflect the average coal inputs and emissions outputs from such boilers, per unit of product (e.g., steam) delivered. This average approach is used both to protect proprietary data of any one plant, and because the data are often used to model numerous instances of a same process type within a supply chain.

The ingredients of an LCA model, whether process-based or economic input/output-based (as in our example) are twofold:

a) production function data specifying the inputs required per unit of product output;
b) emissions coefficients specifying the quantity of each pollutant released to the environment per unit of product output.

The data for (a) comes directly from the national input/output tables. This production function data is then combined with county-level information on the share of each product's local usage that is supplied by local production.

The data for (b) comes from the national Toxic Release Inventory (TRI) latest data year 1999. We calculate national average emissions coefficients by using the total TRI releases to each media for each sector and dividing that amount by the total value of product shipments from each sector. This yields national average, sector-specific emissions coefficients in terms of pounds of TRI per dollar amount of product shipped. Aggregation of both production and release data to the national level helps cancel out reporting errors and stochastic variability in each data set. County-level emissions coefficients would be very resource-intensive to develop and would also lack these error-canceling benefits.

The national average emissions factors may differ from local emissions coefficients for a variety of reasons. If local plants are small enough, or if their use of TRI chemicals is low enough, it may fall under TRI reporting thresholds. Also, of course every plant is likely to differ somewhat from the national average in terms of emissions per unit of output.

For reasons such as this, our model predicts some nonzero toxic releases even from some sectors for which the EPA does not show toxic releases for 1999. Still, as our model results show, the bulk of the total cradle-to-gate emissions come from plants out of the region, whose locations are scattered throughout the U.S. and for which national average emissions coefficients are a wise choice.

A5.0 Conclusions and Recommendations

Earlier in this report, upstream building-related environmental burdens affecting salmon habitat were prioritized from most direct to least direct impact as follows:

- Most direct: Toxic releases to water,
- Toxic releases to land/underground,
- Toxic releases to air,
- Criteria air pollutants,
- Least direct: Greenhouse gas emissions.

For each of these five burdens, the BaselineGreen™ analysis reported the following results:

- Toxic releases to water: Compared to other industries such as paper manufacturing, building related industrial toxic releases to water reported in 1999 were less than 1 percent. This is true for both the three county region and the rest of the State of Washington. These releases to water were made by three wood treatment facilities, one of which is located in the KPS three county region.

- Toxic releases to land: With the exception of refuse, building related industrial toxic releases to land reported in 1999 were zero. This is true for both the three county region and the rest of the State of Washington.

- Toxic releases to air: Compared to other industries, building related industrial toxic releases to air in 1999 were small. The percentage of statewide reported toxic releases to air that can be attributed to building related industries is less than 5% of the total.

- Criteria air pollutants: With the exception of cement building related industrial criteria air pollutant releases in 1999 were small. The cement industry accounts for a fairly large share of all types of criteria air pollutant emissions in the three county region.

- Greenhouse gas emissions: Emissions of CO2 associated with the manufacture of cement (SIC code 3241) and fabricated steel products (SIC code 3441) account for a substantial portion of greenhouse gas emissions in the KPS three county region and possibly a large portion of GHGs in the rest of the state of Washington. Two cement plants and one lime facility in the KPS three county region account for approximately 1.4 million tons of CO2 emissions per year. The CO2 emission total for the one steel product manufacturer in the region is about 250,000 tons per year.

In summary, the BaselineGreen™ analysis revealed a small direct link between upstream environmental burdens associated with the manufacture of building materials and products and environmental factors detrimental to salmon habitat. For the most direct environmental burden, toxic releases to water, building related industries accounted for less than 1 percent of all toxic releases to water for the State of Washington and the KPS three county region reported in 1999. For the second most direct burden, toxic releases to land, no building industries reported in 1999.

It appears that, as the links between upstream environmental burdens and salmon habitat become more and more indirect, the role of building related industries becomes more significant. Several building related industries reported toxic releases to air, for example. However, the building industry share of annual releases is quite small accounting for only about 5% of all toxic air releases in 1999.

Similarly, for criteria air pollutants, several building related industries reported emissions, but the total was small compared to other industries. The one exception in the three county region is the cement industry which accounts for a large share of local air pollutants.

As mentioned earlier, the impact of criteria air pollutants on salmon habitat is indirect. The pollutants must return to land and water via atmospheric deposition. Airshed patterns and monitoring of several sites in western Washington indicate that the area is not susceptible to atmospheric deposition. Additionally, air pollution associated with a building may be much greater during use stage due to energy use over a building lifetime.

Related to global climate change, also an indirect factor affecting salmon habitat, the effect of upstream building related industrial greenhouse gas emissions is similar to that of air pollutants. Again the one exception is the cement industry which likely accounts for a large share of local upstream greenhouse gas emissions. Upstream GHGs however, are quite small compared to energy consumption during the use stage (occupancy) of a building over its lifetime and to other sources of GHGs (e.g., the transportation sector).

Given the above results and conclusions, there are several caveats however:

1. The Toxic Release Inventory (TRI) data used for BaselineGreen™ relies on reports submitted by industries. It is possible that some releases may be un- or under-reported.
2. Establishing direct cause-effect links between specific stressors and salmon is elusive. Scores of studies and scientific reports reference the uncertainties associated with definitive declarations of what are contributing factors to salmon decline.
3. The heightened awareness of persistent bioaccumulative toxins (PBTs) as a class of chemicals may not be matched by the way in which data are currently reported.
4. While the reported toxic releases to water associated with the generic building types' bill of materials areminor, there *are* releases to air of both greenhouse gases (principally CO2) and toxic chemicals. Both of these may result in indirect impacts on salmon: in the case of CO2 releases, the consequent climate change is associated with rising global temperatures; in the case of toxic releases to air, these chemicals disperse and may eventually fall to the ground, impacting land and water quality. Because of the more distributive nature of air releases than water releases, the point source relative to proximity to habitat is of diminished importance, particularly when these releases are PBTs.

These results point to other possible building related activities as having a more significant impact on salmon habitats in the region. Some of these are briefly discussed below.

Upstream in the life cycle of buildings, impacts from the extraction of resources, such as erosion and sedimentation from logging and mining, can be sizeable. BaselineGreen™ is not structured to inventory and map regional erosion and sedimentation related to upstream building activities. Additionally, there are supply chain activities that may have environmental impacts other than the three environmental burden indicators mentioned above. Besides erosion and sedimentation, those impacts include loss of vegetation, other changes in land cover, and fertilizer, pesticide, and herbicide use.

Other impacts occur during the use phase of buildings. These include power sources for electric generation. Perhaps the most important step in developing salmon-friendly buildings is the generation of salmon-friendly power. The purchase of salmon friendly power ideally decreases reliance on dams and diversions that produce power from non-fossil fuel sources but have adversely affected salmon habitat in the process.

On an urban development scale, topics such as impervious cover, dredging, filling, and channelization of streams, landscape and household fertilizer use, and transportation related issues might be significant concerns. As mentioned earlier, these are beyond the scope of work of this report.

Given these conclusions, the following recommendations can be made as salmon-friendly policies and practices. These recommendations follow the format outlined in LEED version 2.0, "Materials and Resources" credits. However, BaselineGreen™ will recommend practices different from LEED in some cases, because its methodology is based on a life cycle assessment (LCA) approach to assessing environmental impacts. These differences will be discussed under the appropriate LEED Credits below.

Promote Building Reuse (LEED Materials and Resources Credit 1)
Reusing large portions of existing structures reduces the need for newly manufactured building materials and products. As described in the three BaselineGreen™ analyses reviewed in this report, every manufactured building material and product is associated with some form of upstream environmental burden. Reusing major portions of existing buildings, such as the structure or shell, can minimize or even avoid some of these burdens.

Promote Resource Reuse (LEED Materials and Resources Credit 3)
Specifying salvaged or refurbished materials can also reduce the need for newly manufactured building materials and products. Similar to building reuse, using recovered materials and products from existing buildings, such as beams, columns, flooring, doors, and windows, can minimize or even avoid upstream environmental burdens.

Promote Recycled Content Materials and Products (LEED Materials and Resources Credit 4)
Recycled content materials and products reduce negative environmental impacts associated with the extraction of new raw materials. Processing of virgin materials consumes both energy and resources and is usually associated with some form of upstream environmental burden.

One major product to examine under this credit is Portland cement. The feasibility of using cement substitutes such as fly ash in the making of concrete products should be investigated. Although only indirectly affecting salmon habitat, cement manufacture is responsible for a huge portion of local and regional air pollution and greenhouse gas emission burdens. These burdens can be greatly reduced with cement substitutes.

Other major products to examine under this credit are structural steel and fabricated steel products. These input items consistently appear as high priorities in terms of upstream environmental burdens for average U.S. construction of all three building types examined in this report. These input items are responsible for a large portion of local and regional air pollution and greenhouse gas emission burdens. These burdens can be greatly reduced by replacing new raw materials with recycled materials.

An LCA approach to assessing environmental burdens reveals that many industrial processes produce usable by-products that are not technically post-industrial or post-consumer recyclables. They are used as processing agents or are physically different than the material or product being manufactured. Fly ash and slag are examples. Under the topic "recycled content materials and products" therefore, BaselineGreen™ recommends the inclusion of by-product materials.

Promote the Use of Local/Regional Materials and Products (LEED Materials and Resources Credit 5)

LEED and BaselineGreen™ differ on their approaches to and recommendations for this topic. LEED recommends using local and regional products "across the board" as a means of reducing upstream environmental impact associated with the transport of goods and materials. However, an LCA approach reveals that there may exist much more harmful upstream burdens during the manufacturing stage of a material or product than during the transport stage. One should not assume outright that local and regional manufacturers have zero environmental burdens associated with their facility. In fact, the BaselineGreen™ analysis of average construction in the U.S. has informed us to initially assume otherwise. Thus, using local and regional materials can be recommended only if some sort of LCA approach is incorporated into the specification process.

Although the three BaselineGreen™ analyses in this report indicated that, for average construction in the entire U.S., many building related materials and products are associated with upstream toxic releases, air pollution, and greenhouse gas emissions, a review of the data suggests that fortunately, local and regional industries in Seattle and the State of Washington have become "cleaner and greener" than the U.S. average. There were no documented toxic releases to water or land from local and statewide building related industries in 1999 and toxic releases to air that can be attributed to building related industries is less than 5% of the statewide total. Therefore, specifying materials and products from local and/or regional manufacturers will not necessarily result in an increase in associated upstream environmental burdens at the local and regional scale. With the exception of cement and fabricated steel products, the same can be said for upstream air pollutant and greenhouse gas emissions.

The above statement is made with caution. Many local and regional building related industries did report toxic releases to water, land, and air in previous years. Constant monitoring of upstream manufacturing impacts must be a part of any "buy local" program. The BaselineGreen™ analyses have indicated that careful attention should be paid when specifying the building materials and products listed below. These are products that consistently appear as "high priority" inputs in average U.S. construction but local and regional manufacturers were found to be "cleaner and greener."

- Rough lumber products and processed lumber products such as plywood, waferboard, millwork, and wood cabinets (SIC codes 2421, 2426, 2431, 2436, 2491, 2493).

- Cement (SIC code 3241).
- Structural steel and fabricated steel products (SIC codes 3441, 3449).
- Paints (SIC code 2851).

Cement and steel have been discussed above under Materials and Resources Credit 4. Lumber is discussed below under Materials and Resources Credit 7.) Although paint products are addressed in LEED version 2 under Indoor Environmental Quality Credits, that topic does not address the concerns raised by BaselineGreen™. The upstream impacts of paint manufacture are better addressed as a "materials and resources" topic. The recommendation regarding paints is to comply with standards for chemical content set by Green Seal third party certification guidelines.

Promote the Use of Certified Wood Products (LEED Materials and Resources Credit7)
As mentioned above, rough and finish wood products consistently appear as "high priority" inputs in average U.S. construction. However, with the exception of criteria air pollutant emissions, local and regional manufacturers were found to be "cleaner and greener" than the U.S. average. Although only indirectly affecting salmon habitat, the processing of finished wood products such as millwork and plywood is responsible for a huge portion of local and regional air pollution and greenhouse gas emission burdens. Specifying products certified by an independent third party program is one step that can be taken to begin to minimize the environmental impact of wood product manufacturing in the region.

Promote the Use of Naturally Resistant Lumber and Alternatives to CCA Treatment
This recommendation is in response to the fact that all known building related toxic releases to water in the three county region and Washington State are from wood treatment facilities that either use creosote or the chromated copper arsenic (CCA) process. Naturally resistant lumber (which should, of course, come from a sustainably managed forest), such as redwood or cedar is pest resistance without chemical treatment. Alternatives to the CCA process include ACQ (Ammoniacal Copper Quaternary), CBA (Copper Boron Azole), boron, and plastic wood made from recycled polyethylene and wood or other cellulose fibers.

Appendix B:

Wingspread Statement on the Precautionary Principle

This statement was drafted and finalized at a conference at the Wingspread Conference Center, Racine, Wisconsin, which took place 23-25 January 1998. The 32 authors of the statement are listed beneath the statement.

The release and use of toxic substances, resource exploitation, and physical alterations of the environment have had substantial unintended consequences on human health and the environment. Some of these concerns are high rates of learning deficiencies, asthma, cancer, birth defects and species extinctions; along with global climate change, stratospheric ozone depletion; and worldwide contamination with toxic substances and nuclear materials.

We believe existing environmental regulations and other decisions, particularly those based on risk assessment, have failed to adequately protect human health and the environment, as well as the larger system of which humans are but a part.

We believe there is compelling evidence that damage to humans and the worldwide environment, is of such magnitude and seriousness that new principles for conducting human activities are necessary.

While we realize that human activities may involve hazards, people must proceed more carefully than has been the case in recent history. Corporations, government entities, organizations, communities, scientists and other individuals must adopt a precautionary approach to all human endeavors.

Therefore it is necessary to implement the Precautionary Principle: Where an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

In this context the proponent of an activity, rather than the public bears the burden of proof.

The process of applying the Precautionary Principle must be open, informed and democratic, and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action.

Wingspread conference participants:

(Affiliations noted for identification purposes only.)

* Dr. Nicholas Ashford, Massachusetts Institute of Technology
* Katherine Barrett, Univ. of British Columbia
* Anita Bernstein, Chicago-Kent College of Law
* Dr. Robert Costanza, University of Maryland
* Pat Costner, Greenpeace
* Dr. Carl Cranor, Univ. of California, Riverside
* Dr. Peter deFur, Virginia Commonwealth Univ. Gordon Durnil, attorney
* Dr. Kenneth Geiser, Toxics Use Reduction Institute, Univ. of Mass., Lowell
* Dr. Andrew Jordan, Centre for Social and Economic Research on the Global Environment, Univ. Of East Anglia, United Kingdom
* Andrew King, United Steelworkers of America, Canadian Office, Toronto, Canada
* Dr. Frederick Kirschenmann, farmer
* Stephen Lester, Center for Health, Environment and Justice
* Sue Maret, Union Institute
* Dr. Michael M'Gonigle, University of Victoria, British Columbia, Canada
* Dr. Peter Montague, Environmental Research Foundation
* Dr. John Peterson Myers, W. Alton Jones Foundation
* Dr. Mary O'Brien, environmental consultant
* Dr. David Ozonoff, Boston University
* Carolyn Raffensperger, Science and Environmental Health Network
* Dr. Philip Regal, University of Minnesota
* Hon. Pamela Resor, Massachusetts House of Representatives
* Florence Robinson, Louisiana Environmental Network
* Dr. Ted Schettler, Physicians for Social Responsibility
* Ted Smith, Silicon Valley Toxics Coalition
* Dr. Klaus-Richard Sperling, Alfred-Wegener- Institut, Hamburg, Germany
* Dr. Sandra Steingraber, author
* Diane Takvorian, Environmental Health Coalition
* Joel Tickner,University of Mass., Lowell
* Dr. Konrad von Moltke, Dartmouth College
* Dr. Bo Wahlstrom, KEMI (National Chemical Inspectorate), Sweden
* Jackie Warledo, Indigenous Environmental Network

Appendix C:

Salmon-Friendly LEED Overlay

LEED™ 2.0	Salmon Impact Category	Life Cycle Phase	Recommended Salmon-Friendly Strategies	Regulatory Impact	Technical Requirements	Cost Impact
Sustainable Sites						
SS Prerequisite 1: Erosion & Sedimentation Control - Control erosion to reduce negative impacts on water & air quality	Water Quality	Use	Implement BMPs as established by "Stormwater Management Manual for Western Washington", August 2001, developed by Washington Department of Ecology	Seattle BMPs are equivalent and in some cases more stringent than the EPA referenced standard	to be determined	to be determined
SS Credit 1.0: Site Selection	Water Quality	Upstream / Use	Establish buffer zone from riparian areas, consistent with the Salmon-Safe® Farm Management Certification Program 2.0, or most current version, developed by the Pacific Rivers Council; on slopes of ≥10%, riparian zones should be no less than 50 feet and buffer zones should be vegetated with native plants; for established riparian zones, canopy cover should be >50% of mixed multi-aged, native species; for newly established plantings, design for maximum diversity.	See Seattle Urban Blueprint for Habitat Protection & Restoration, June 01	See Salmon-Safe® Farm Management Certification Program requirements	to be determined
SS Credit 2.0: Urban Redevelopment	Water Quality	Use	Assess existing total impervious area (tia) in the identified urban watershed; design new construction and retrofit existing construction so that tia does not exceed 10%	Determine how existing zoning regulations for allowing impervious cover requires change	Evaluate efficacy of strategies to reduce stormwater runoff including pervious paving materials, rainwater catchment, green roofs; review studies by Washington Aggregates & Concrete Association and University of Washington's Center for Urban Water Resources Management as related to local soils	varies depending on strategy
SS Credit 3.0: Brownfield Development	Water Quality	Upstream	Ensure that disturbance of contaminated site does not result in the uncontrolled release of hazardous materials, as with stormwater run-off, particularly in watersheds with salmon habitat	Review existing remediation requirements for brownfield sites	to be determined	to be determined
SS Credit 4.4: Alternative Transportation	Water Quality	Use	Parking represents about 10% of land use in urban areas. Determine watershed scale total impervious area. For watersheds that exceed 10%, pursue parking strategies that result in no net increase achieved through elimination of surface parking, parking structures with installed rainwater collection or green roof, or pervious paving options.	Establish watershed-scale impervious area surveys with a not to exceed level of 10%; new buildings should pursue no-net increase strategies; existing buildings should be retrofitted	Evaluate efficicacy of pervious paving strategies & evaluate incentives	to be determined
SS Credit 5: Reduced Site Disturbance	Water Quality	Upstream / Use	Strengthen requirement in riparian buffer zone as consistent with the Pacific River's Council's Salmon-Safe Certification Guidelines currently under revision. On slopes of ≥10%, riparian zones should be no less than 50 feet and buffer zones should be vegetated with native plants	Consider zoning ordinance requiring minimum 50 feet riparian zone for slopes ≥10%.	to be determined	to be determined
SS Credit 6: Stormwater Management	Water Quality	Use	Existing codes provide equivalent performance.	Monitor implementation of existing codes to determine effectiveness.	to be determined	to be determined
SS Credit 7: Landscape & Exterior Design to Reduce Heat Islands - Reduce heat islands to minimize impact on microclimate & human & wildlife habitat	Water Quality (temperature)	Use	Establish appropriate shading strategies to balance impervious cover, including from natural vegetation & from constructed shade systems; employ green roof & rainwater harvesting systems	Calculate total impervious cover by watershed; incentivize strategies to reduce heat islands	Evaluate effectiveness of off-the-shelf green roof systems; identify effective shading strategies (vegetative & non-vegetative)	varies depending on strategy

LEED™ 2.0	Salmon Impact Category	Life Cycle Phase	Recommended Salmon-Friendly Strategies	Regulatory Impact	Technical Requirements	Cost Impact
Water Efficiency						
WE Credit 1: Water Efficient Landscape - Limit or eliminate the use of potable water for landscape irrigation.	Water Quantity	Use	Specify native plants that minimize water requirements for irrigation; derive irrigation water from non-potable sources, e.g., collected rainwater, greywater		See City of Seattle Salmon-Friendly Gardening Guidelines	n/a
WE Credit 2: Innovative Wastewater Technologies	Water Quality; Water Quantity	Use	On-site wastewater treatment systems, water re-use, dual-flush toilets, waterless urinals, composting toilets	Determine whether any code restrictions on installing compost toilets, on-site wastewater treatment systems within City of Seattle limits		low to high
WE Credit 3: Water Use Reduction - Maximize water efficiency within buildings to reduce the burden on municipal supply and wastewater systems.	Water Quantity	Use	Dual-flush toilets, waterless urinals, composting toilets, infrared sensors; reuse rainwater & graywater for non-potable uses		See City of Seattle 1% for Conservation Program	low to moderate; City of Seattle provides a $120 rebate for waterless urinals
Energy and Atmosphere						
EA Prerequisite 1: Fundamental Building Systems Commissioning	Water Quality; Water Quantity	Use	Commissioning will ensure that mechanical systems (plumbing, electrical) are performing in a manner consistent with the Design Intent, and contributes to efficient water and energy performance.		Commissioning scope should be integrated into design process, beginning in pre-design.	Depends on size/complexity of project
EA Prerequisite 2: Minimum Energy Performance - Establish the minimum level of energy efficiency for the base building and systems.	Water Quality	Use	Use integrated design process to optimize energy efficiency	City of Seattle requires minimum 20% reduction for new construction, 10% reduction for existing building relative to ASHRAE 90.1-1999	Engage in whole building design incorporating passive solar, integrated systems, reduced plug loads.	
EA Prerequisite 3: CFC Reduction		Upstream / Use	Eliminate the use of CFCs as salmon are vulnerable to increased ultraviolet radiation exposure	Requirement in place	n/a	n/a
EA Credit 1: Optimize Energy Performance	Water Quality	Use	Meet and exceed Seattle's energy performance requirements	City of Seattle requires minimum 20% reduction for new construction, 10% reduction for existing building relative to ASHRAE 90.1-1999	Engage in whole building design incorporating passive solar, integrated systems, reduced plug loads.	Any higher first costs generally recouped in operational savings in 3-5 years
EA Credit 2: Renewable Energy	Water Quality; Water Quantity	Use	Identify non-hydro renewable sources such as wind, biomass and photovoltaics; pursue site design to optimize solar / wind access as appropriate	Determine availability of financial incentives from local utility, state or federal governments		
EA Credit 3.0: Additional Commissioning	Water Quality; Water Quantity	Use	Ensure that plumbing systems are included in scope in recommissioning manual	n/a		
EA Credit 4.0: Ozone Depletion		Use	Balance reduction of ozone depleting compounds with global warming potential, recognizing that both are contributing factors to salmon decline; specify non-ozone depleting refrigerants and fire suppressants as available and balanced with global warming potential		Monitor energy performance of ozone-friendly mechanical systems and specify as their global warming potential is equivalent to or less than systems using HCFCs and other ozone depleting compounds	high

LEED™ 2.0	Salmon Impact Category	Life Cycle Phase	Recommended Salmon-Friendly Strategies	Regulatory Impact	Technical Requirements	Cost Impact
Energy and Atmosphere (continued)						
EA Credit 5.0: Measurement & Verification			Consider benefit of continuous monitoring relative to scale / complexity of building type and associated costs			low to high
EA Credit 6.0: Green Power			Establish contract with green-energy provider, such as is currently provided by Seattle City Light & other northwest energy suppliers; ensure that hydro sources are upgraded to accommodate specific salmon concerns	State of Washington requires energy suppliers to provide green energy option beginning 2002; evaluate upgrading of regional hydro sources		low price premium for most green energy options in the short term; likely savings in the long term
Materials & Resources						
MR Prerequisite 1: Storage & Collection of Recyclables	Water Quality; Water Quantity	Use	Using recycled content feedstock for manufacturing can lessen associated water impacts	Monitor water use and discharge andn other emissions associated with recycled-content manufacturing feedstocks		
MR Credit 2.0: Construction Waste Management:	Water Quality; Water Quantity	Upstream	Recovering construction & demolition debris and recycling it into new products can lessen the environmental burdens associated with manufacturing with virgin materials, particularly materials that are recycled in the region; ensure that local/regional recycling practices are not resulting in emissions greater than for virgin-based manufacture	Monitor water use and discharge andn other emissions associated with recycled-content manufacturing feedstocks		potential for cost savings
MR Credit 3.0: Resource Reuse	Water Quality; Water Quantity	Upstream	Reusing building materials can lessen the environmental burdens associated with manufacturing with virgin materials, especially those sourced/manufactured in close proximity to salmon habitat; the Resource Building Materials Exchange (RBME) is a source of used materials available to residents of King, Pierce, Thurston & Mason counties.	Evaluate whether there are regulatory constraints for using salvaged building materials; develop recommendations to facilitate safe reuse of building materials, particularly for structural applications	Ensure that reused materials are compliant with code requirements, parti-cularly for structural mater-ials and plumbing and electrical fixtures	potential for cost savings
MR Credit 4.0: Recycled Content	Water Quality; Water Quantity	Upstream	Specify materials with recycled content that adhere to manufacturing practices that are water efficient and have no or low emissions, particularly those that are persistent, bioaccumulative and toxic. Specify high volume fly ash cement concrete mixes to substitute for portland cement. Specify recycled-content and industrial by-product alternatives to virgin sand and aggregate for concrete mixes and other civil applications, such as pipe bedding material.		Adopt ASTM C1157 Standard Performance Specification for Hydraulic Cement (a performance-based specification designed for implementation of blended cement concrete mixes); evaluate use of Processed Glass Aggregate (PGA) as a substitute for virgin aggregate in paving and concrete mixes, pipe bedding materials; Evaluate use of Recycled Asphalt Pavement (RAP) in asphalt mixes.	
MR Credit 5.0: Local/ Regional Materials	Water Quality; Water Quantity	Upstream	Baseline Green™ provides information on the upstream impacts of the bill of materials; specify materials and products that do not result in the release of persistent bioaccumulative toxins through their life cycle and that adhere to best manufacturing practices for their industrial sector		Identify manufacturer-specific operations performance for all manufacturing facilities within watersheds where salmon habitat exist; for small quantity generators seek emissions data that are not reported for U.S. EPA Toxic Release Inventory	potential for cost savings using local/ regional manufacturers

LEED™ 2.0	Salmon Impact Category	Life Cycle Phase	Recommended Salmon-Friendly Strategies	Regulatory Impact	Technical Requirements	Cost Impact
Materials & Resources (continued)						
MR Credit 7: Certified Wood	Water Quality; Water Quantity	Upstream	Forest Stewardship Council remains the only wood-certification protocol that maintains indpendent third-party verification, and is the only certification recognized by the U.S. Green Building Council LEED™. FSC's Pacific Coast (USA) Region has released draft 6.0, to apply to all forests in Washington, Oregon and California, reflecting heightened recognition of the unique ecological features therein.	Seattle City Council Resolution 30015, passed on9/7/99: "The Executive Services Director shall report back to the City Council with a status report and recommendations on strategies for implementing the intent of this resolution no later than December 31, 1999". This resolution was primarily directed at paper purchases and utility poles. No follow-up action has occurred as directed. A City resolution specific to building-related wood procurement is recommended.	Provide adequate lead-time in ordering to ensure FSC-certified product availability	none to higher
Indoor Environmental Quality						
IEQ Credit 4.2: Low Emitting Materials - Paints & Coatings to meet or exceed VOC & chemical component limits of Green Seal requirements	Water Quality	Upstream	Green Seal prohibits the use of toxic chemicals in their approved paints; many of the prohibited chemicals are persistent bioaccumulative toxins, therefore specifying GreenSeal compliant paints reduces the quantities of pbts released in the global environment			none
IEQ Credit 5.0: Indoor Chemical & Pollutant Source Control	Water Quality	Use	Adopt green housekeeping procedures that eliminate use of chemicals; for any liquid chemicals used in the building, ensure proper disposal in appropriately configured plumbing drains and pipes			low
Innovation and Design Process						
Persistent Bioaccumulative Toxins (PBTs)	Water Quality	Upstream	Disallow use of building materials responsible for the release of persistent bioaccumulative toxins through their life cycle (manufacture, use, post-use/disposal). Because of their persistence and bioaccumulative properties, PBTs are a concern beyond their point source and are found throughout the planet.	State of Washington Department of Ecology has adopted a PBT strategy prioritizing several pesticides and several related to building materials including dioxins and furans and mercury.	Evaluate material specifications to eliminate products that release PBTs through their life cycle	none to low